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The Sidereal Messenger.

CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory.

SEPTEMBER AND OCTOBER, 1887.

CONTENTS:

Thou Lord in the beginning hast laid the foundation of the earth, and the heavens are the works of thy hands.

ARTICLES:—	PAGE.
The Time Service of the Lick Observatory.—JAMES E. KEELER,.....	233
The Relation of Aerolites to Shooting Stars.—PROF. D. KIRKWOOD,.....	248
Life and Achievements of Alvan Clark.—THE EDITOR,.....	250
Yale College Measurement of the Pleiades.—A. M. CLERKE,.....	254
Note from MR. PROCTOR,.....	259
Total Eclipse of the Sun, August 19, 1887.—Translated from <i>Ciel et Terre</i> , by DR. C. H. WILSON,.....	262
Star of Bethlehem.—THE EDITOR,.....	265
New Work on Astronomy.—R. A. PROCTOR,.....	270
Colors in the Solar Corona.—J. ENNIS,.....	273
Astronomy in Recent Periodicals.—THE EDITOR,.....	281

EDITORIAL NOTES:—

Recent Showers of Meteors by W. F. DENNING of England.—Comet f 1887 (Brooks), Elements and Ephemeris.—Miscellaneous Observations from Chabot Observatory by CHAS. BURCKHALTER and CHARLES B. HILL.—Magnitudes of Stars for Nautical Almanacs.—Total Solar Eclipse of Aug. 19.—Notes by F. P. LEAVENWORTH on General Catalogue 4333.—Improved Elements and Ephemeris of Comet f 1887 by H. V. EGBERT, Dudley Observatory.—Lick Observatory.—Corregenda in Various Star Catalogues by DR. C. H. F. PETERS,..... 287-296

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Director of Carleton College Observatory, Northfield, Minnesota.

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THE TIME SERVICE OF THE LICK OBSERVATORY.

JAMES E. KEELER.*

For the MESSENGER.

The distribution of time by electric signals to railroad and telegraph companies, cities, private business firms, and other corporations or individuals, for commercial purposes, forms at the present day a part of the routine work of a number of the larger observatories in the United States. The advantages of these "time services" are manifold, and hardly need to be pointed out. A greater degree of accuracy and uniformity is secured than would be possible in any other way, and these are considerations which are daily becoming of greater importance. Chronometers and other time-pieces can be easily and accurately rated without the expensive instrumental outfit of an observatory and the skill required for its use, at any place where telegraphic communication can be had. The astronomer on his part finds the establishment of an already perfected system of time distribution of great service on occasions of special interest to him, such as transits and eclipses, when it is not usually possible to make the necessary observations at fixed observatories, and many observations of value are obtained which would otherwise be lost. A less obvious, but not the less important consideration, is the connection which is thus formed between the more abstruse work of the observatory and the ordinary affairs of every day life, bringing continually before the mind of the public the practical applications of astronomical science, and inspiring confidence in the accuracy of its methods.

* In charge of the Time Service at Lick Observatory, Mt. Hamilton, California.

It was eminently proper that the Lick Observatory, the only large and completely organized institution of the kind on the Pacific coast, should be the center of such a system of time distribution for the surrounding country, sending its clock signals far enough to connect with the already established systems in the East. Accordingly in the early part of the year 1886, contracts for supplying time by automatic signals from a clock were made by Professor Holden, on behalf of the Lick trustees, with the Southern Pacific and other companies. I was invited to come out and take charge of the time service, and arrived on the mountain in April of the same year, but on account of unexpected delays in running the necessary telegraph lines and providing proper instruments, formal notice of the beginning of signals according to the contracts was not given until the first of January, 1887. Since that time the performance of everything connected with the system has been gradually improved until it is now perfectly smooth and satisfactory.

In the following account of the time service which has thus been established, I do not purpose to describe the well known methods for finding time, regulating clocks, etc., but to state the practice at this observatory, with such modifications of the usual methods as experience has shown to be advantageous, either on account of the instruments at command, or the unusual circumstances in which the observatory is placed. It will be understood that a great part of the apparatus which is used in the ordinary process of determining time is not specially intended for these purposes only, but forms an integral part of the instrumental outfit of the observatory.

The transit instrument is mounted in a room adjoining the large meridian circle house on the west. It has an object glass by Clark & Sons, 4.1 inches in clear aperture, and of 47.0 inches focus. Its optical qualities are excellent, and I have several times seen the companion of Antares with it, when that star was in transit. The mounting is by Fauth & Co., is well made and satisfactory. The piers are heavy, open frameworks of cast iron, covered by walnut jackets, and were used

as at first set up for some time, but as the azimuth and level constants of the instrument varied considerably from night to night, they were subsequently filled with brick and Portland cement, by which their stability was greatly increased. The pivots are of bronze, 2.1 inches in diameter, and rest in agate Y's. They are sensibly cylindrical, but slightly unequal in size, the correction to the level constant on this account being $-0.021s$ for clamp west. Part of the weight of the instrument is relieved by counterpoises. For reversing, which requires about $3\frac{1}{2}$ minutes, a special carriage is provided. On one end of the axis is a circle 16 inches in diameter, coarsely divided on the edge to $20'$, with a level alidade reading by two verniers to $1'$. This circle is used as a finder, and is set to read zenith distances.

In 1885 the instrument was sent back to the makers and remodeled by them according to designs by Professor Holden, so as to serve also as a zenith telescope. A finely divided circle reading to $10''$, with latitude level, was put on the other end of the axis, and the micrometer was made to rotate 90° between adjustable stops, so as to move in declination when desired. The finely divided circle is symmetrical with the finder, and marks the clamp end of the axis.

The glass reticle plate contains thirteen vertical lines, and one horizontal line to mark the center of the field. Of the vertical lines only the central group of five is used. The equatorial interval between two lines of this group is $1.170s$, which is perhaps a little too small. At the zenith the interval is $1.472s$. Whole revolutions of the micrometer, which carries a single spider's thread, are registered on a dial outside the box. The value of one revolution is $2.931s$.

The illumination is effected by a lamp, placed on a stand about six feet from the west end of the axis. It is so easy to rotate the illuminating mirror in the telescope when the transit is reversed that I have not placed a lamp on the opposite side.

The system of electrically controlled finding clocks which has recently been introduced into the observatory deserves

especial mention. All the standard clocks are in a room in the main building, and can only be seen from the window opening from this room into the long hall. At all instruments where an approximate knowledge of the sidereal time is necessary, clocks provided with electric control (Gardner's patent) have been set up, and connected by the same line with a Leclanché battery of four cells in the battery room. The wires lead also through a button near one of the standard sidereal clocks in the clock room. When this button is touched the minute and second hands of all the finding clocks in the circuit spring to zero, and it is only necessary to do this at the proper time, *i. e.*, at any even hour, to set all the clocks.

These finders, which will run several days without varying more than a few seconds, are even more convenient than a standard sidereal clock near at hand would be, as they can always be set to show the true sidereal time, and the observer is not troubled with allowance for error of the clock. The dial and hands are moreover larger, and easier to see at a distance. Other clocks of the same kind regulated to mean time, have been placed in the dwelling houses below the observatory, and are set by touching a button in front of the standard mean time clock. The same battery furnishes the current for these clocks, as well as for other electrical instruments in the observatory which are only occasionally brought into use. The cost of each clock, including the electric control, was \$25.

The sidereal finder in the transit house is on a stone pier, originally intended for a standard clock, near the wall on the west side of the transit, where it can be seen from any part of the room.

The chronograph ordinarily used is on the north-side of the same room. It was made by Fauth & Co., and its performance is good. It is unnecessary to say that everything tending to the convenience and comfort of the observer has been provided.

The meridian of the Fauth transit has been adopted as the standard meridian of the observatory. The dome of the 12-inch equatorial has been connected by the Coast Survey with

the primary triangulation of the Pacific coast, and reducing the coördinates of this point to the center of the mercury basin of the transit, we have for the position of the latter,

$$\begin{aligned}\varphi &= 37^{\circ} \ 20' \ 24.56'' \\ \lambda &= 8\frac{1}{2} \ 6m \ 34.29s \text{ west of Greenwich.}\end{aligned}$$

The latitude determined by Prof. Comstock from a preliminary reduction of observations made with the meridian circle during the summer of 1886 differs from that of the Coast Survey by only 0.4".*

The observatory possesses five astronomical clocks and five chronometers. All of the clocks are mounted on piers in a room specially constructed for the purpose in the main building, where they are protected from dust, fog and sudden changes of temperature. The sidereal clock which has been most used in connection with the time service is mounted in a closet, itself with double walls and doors, on the west side of the clock room. It was made by E. Dent & Co. of London, has a gravity escapement and mercurial pendulum, and is of very beautiful workmanship throughout. On account of changes made in the positions of the clocks, and on account of experiments which were made for the adjustment of the temperature compensation of their pendulums, etc., none of these clocks has been allowed to run for any length of time without disturbance. Below are given the rates of the Dent clock for the longest interval during which it has been suffered to run uninterruptedly in its present position.

Date.	Mean Temp.	δT	Date.	Mean Temp.	δT
1887, March 1...	31	- 0.08	1887, March 20..	52	- 0.03
4...	41	- 0.06	25..	53	- 0.11
6...	45	- 0.08	27..	54	- 0.10
8...	45	- 0.13	29..	56	- 0.05
10...	48	- 0.05	31..	56	+ 0.03
13...	51	+ 0.09	April 3..	57	+ 0.01
15...	52	+ 0.05	5..	58	- 0.04
18...	54	+ 0.03	7..	58	- 0.02

* SIDEREAL MESSENGER, December, 1886.

The average height of the barometer was 25.80 in., and the extreme variation 0.30 in.

The other sidereal clocks have been occasionally used. Two by Hohwü of Amsterdam, with dead beat escapements, run quite as well as the Dent clock.

The mean time clock was made by E. Howard & Co. of Boston. It is mounted on a pier in the clock room, in front of the window opening into the main hall, where it can be seen from the switch board outside. This clock is kept 6m 34.29s fast of the local mean time of the transit instrument, and therefore indicates the time of the 120th meridian from Greenwich, or Pacific Standard Time. In construction it is similar to the clock used for the same purpose at the Washburn Observatory in Madison, Wisconsin. The pendulum carries a cluster of four steel jars filled with mercury, and has a dead beat escapement. Through inexcusable carelessness of construction the verge of the escapement, when the instrument was received from its makers, was so put on its arbor that the teeth of the scape-wheel struck sometimes on the jeweled pallets and sometimes on the steel frames in which the pallets are set. The rate of the clock was naturally very irregular. After this had been remedied by resetting the verge, the clock performed very well, and has since given entire satisfaction. The pendulum is provided with a nut turned by short spokes, traversing a thread cut on the pendulum rod a short distance above the bob, for regulating its rate, but as the act of turning this nut disturbs the pendulum to some extent, and the rate is greatly affected by variations in the arc of vibration, its use has been abandoned and the rate adjusted entirely by the use of weights, the smallest of which produces a change of 0.1s per day. The weights most frequently used for correcting small errors are cut to produce a change of 0.1s per hour. Each is provided with a projecting pin for lifting and weighs 4.64 grammes. For convenience the clock is kept with a slightly losing rate, and the application of one of these weights to the top of the pendulum is required about an hour every day.

The apparatus for repeating the beats of the clock by electricity is arranged as follows: The scape-wheel arbor carries a steel wheel originally with 30 teeth, the 30th being cut away. At every even second except the 58th one of these teeth lifts a spring and breaks an electric circuit. The second wheel of the train drives a five-minute wheel with smooth rim, in which a notch ten seconds long is cut. Immediately after the fiftieth second, preceding every even fifth minute a catch falls into this notch and short-circuits the two-second break, so that the latter does not operate until the beginning of the next minute. The relay connected with the clock beats therefore even seconds of Standard Pacific Time, omitting the 58th second of *every* minute, and the 52, 54, 56 and 58th seconds preceding every *even fifth* minute.

On the switch board outside the clock room are, besides other instruments, five "back contact" relays of low resistance, one for each of the five clocks. From these relays, which take the place of the clocks for all time observations, either make or break-circuit signals can be sent, no matter what the arrangement of the electric apparatus in the clocks may be. Only feeble currents are sent through the clocks. The switch board need not be described. Its arrangement is so simple, notwithstanding the number of instruments leading to it, that any desired connection can be made in a moment even in the dark, and with any battery power required. At the left end of the switch board is a relay marked "receiving magnet," which through the day is connected with the back-contact relay of the No. 7 or mean time clock. Through the relay points of the receiving magnet passes the main line from the observatory to San Jose, and the current on this line is therefore interrupted simultaneously with the beats of the No. 7 clock relay.

The observatory is connected with a large relay for repeating the time signals in the railroad office of the Southern Pacific Company in San Jose, by twenty miles of No. 9 iron wire, and it is responsible for the proper working of this relay. This telegraph line runs for a great part of the way through

wild and mountainous country, and for several miles at the upper end is exposed in winter to violent storms. The care of the transmitting line is therefore much greater than in most other time services, where sometimes the instrument at which the responsibility of the observatory ceases is in the building itself.

The relay in San Jose opens or closes simultaneously four different circuits, which will be described separately further on. It is at one end of the operator's table in the railroad office, and is enclosed in a glass case to exclude the dust. Above it on a shelf are four indicators, one for each pair of relay points, through which the circuits interrupted by the relay are led to show that good contact is made at every beat of the instrument. Four corresponding switches outside the glass case allow the relay points to be cut out of circuit when the clock signals are not desired on the local lines. The relay is wound to a resistance of 150 ohms. The responsibility of the observatory for the proper transmission of time-signals ceases at this point.

The line to San Jose is led at the observatory through a lightning arrestor (not often needed in this climate) on the switch board, and a relay having a resistance of 150 ohms, placed on a bracket near the clock room window. This relay serves merely as an indicator. The end of the line at the observatory is grounded by connection with the system of water pipes. The resistance of the line, including the indicator and the four point relay at the other end, is about 800 ohms. A battery of 18 gravity cells is used. In fine weather 5 of these cells are just sufficient to work the instrument in San Jose.

On the same poles with the time line is strung a telephone wire of the same size, also the property of the observatory, connecting the dwelling house on the mountain with the central telephone office in San Jose, which is about a quarter of a mile nearer to the observatory than the railway station. There are three intermediate telephone stations on this line, at approximately equal distances apart, known as "Smith's Creek," "Snell's Ranch" and the "Junction House," in the order of

distance from the summit. The two wires are liable to cross in severe storms, by breaking of the poles or insulators, and it is a matter of importance to have some means of locating the fault.

When both lines are in good order, the beats of the clock can be distinctly heard in any of the telephones, by induction between the two wires, although they are not loud enough to interfere with conversation. When a cross occurs, however, the powerful current from the main battery divides between the lines, a part reaching the earth through both ends of the telephone wire, and violent concussions are produced in all the telephones. If the observatory end of the telephone wire is then disconnected from the ground, the beats will cease to be heard (except very faintly) at stations between the cross and the observatory, and continue as before between the cross and San Jose. In this way the two stations can be determined between which the cross occurs.

Accidents are most liable to happen between the summit and Smith's Creek, where the line is most exposed to severe weather, and it is desirable to locate the position of a cross here with some degree of precision. A tangent galvanometer is kept near the clock room at the observatory, and can be introduced at any time into the main line. In fine weather, with the line in good condition, the 18 cells will produce a deflection of the galvanometer needle of 47° , and the battery is cleaned when the deflection falls below 40° . When a cross occurs the current divides as above mentioned, the total resistance of the circuit is diminished, and the galvanometer deflection is increased. By observing the deflection (1) with both ends of the telephone line open, (2) with the observatory end open and the San Jose end grounded, (3) with the San Jose end open and the observatory end grounded, the position of the cross can be determined with considerable accuracy. The changes in the connection of the San Jose end are easily arranged by communication with the attendant in the central telephone office, the clock being temporarily disconnected for the purpose. The battery of 18 cells is sufficiently powerful

to work the relay in San Jose, even when a large part of the current is diverted by contact with the telephone wire, but all communication on the latter under these circumstances is stopped.

The San Jose relay is allowed to beat from 9 A. M. to 6 P. M. every day except Sundays. The mean time and sidereal clocks are compared just before 9 A. M., and the former adjusted so that its error shall be as nearly as possible zero at noon, when a special signal is sent, according to the following programme: At 23^h 50^m the usual break-circuit signal is changed to a make-circuit one (as such signals are less liable to interruption in telegraphing), by reversing the switch of the back-contact relay, and made long by proper adjustment of the tension of the armature springs. At 23^h 56^m the clock is cut off, and the armature of the receiving magnet is rattled or *time* called until 23^h 57^m. The clock remains disconnected from 23^h 57^m to 23^h 57^m 58^s, when it is switched in again, so that the first beat heard at a distance after the pause of one minute is 23^h 58^m 0^s. The clock is then allowed to beat two minutes, omitting as usual the 58th second of the 58th minute and the 52, 54, 56 and 58th seconds of the 59th minute. At 0^h 0^m 1^s the clock is cut off, and the last beat heard at a distance is therefore 0^h 0^m 0^s or noon. The usual break-circuit signals are begun again at the end of about five minutes.

It is evident that the time can be told precisely at any distant instrument, at any time between 9 A. M. and 6 P. M. provided that a person there has the means of identifying the fifth minute indicated by the long pause of 10 seconds, *i. e.*, provided he knows the time already to within 2½ minutes.

Besides the standard sidereal clock, two mean time chronometers are used, and are compared with the Howard clock three times daily; at 9 A. M., at noon (immediately after the special signals) and at some time in the evening. One of the chronometers, Negus 1719, has nearly as uniform a rate as a good clock. The other is a fair instrument. The comparisons are made by ear, using a sounder in the clock room worked by the relay points of the receiving magnet. Taken in connec-

tion with the morning comparisons, they give a check on the error of the noon signals.

The sidereal clock correction is determined, on an average, about every other evening. In arranging a system of observation which should give the greatest degree of accuracy with the least expenditure of time and labor, regard was paid to the following facts, due to the peculiar situation of the observatory and the manner in which the instruments are mounted : 1. For the greater part of the year, during the summer and autumn months, observations can be made whenever desired, so far as the atmospheric conditions are concerned. 2. During the winter months very heavy fogs prevail, which, however, seem often to extend very little above the top of the mountain, and frequently bright stars near the zenith can be very well observed when the whole mountain top is shrouded in dense clouds. 3. Facilities were at hand for erecting a suitable mark from which the azimuth and collimation of the instrument could be obtained at any time.

Twenty-nine feet immediately south of the Fauth transit, on a brick pier, is the 5-inch object glass of the photoheliograph, an instrument in all respects similar to those employed by the parties sent out by the United States government to observe the last Transit of Venus, and forty feet south of this, on a pier in a photographic laboratory constructed for the purpose, is the plate-holder of the same instrument. The objective thus forms an admirable collimator for the transit, and as both piers are substantially built and well protected from the weather, it was probable that the azimuth of a mark observed through the collimator would be subject to but little change. A mark was made by fastening on to an adjustable iron frame secured to the base plate of the photographic plate-holder a piece of glass cut from an old "fogged" dry plate, on which fine lines had been ruled with a knife so as to scratch through the collodion film. The visual focus of the photoheliograph lens is about three inches longer than the photographic focus, so that the mark does not at all interfere with the plate-holder. When the mark is illuminated by a hand lamp and

viewed with the transit instrument, the scratches appear as fine, bright vertical lines on a darker background, and they can be bisected by the micrometer thread with great precision.

Experience showed that the azimuth of the mark was very nearly constant. It has been determined carefully about once a month since first set up, but the changes have hardly been more than the probable error of observation. In determining the azimuth of the instrument from that of the mark, the central line of the latter is assumed to be $0.13s$ west of south.

For the regular routine determinations of the clock correction for time-service purposes, I have arranged the stars of the Berliner Jahrbuch and the American Ephemeris in fifty-three lists, which are consequently about half an hour apart. The ideal construction which I have endeavored to approach as closely as possible in making out these lists, is as follows: Each list consists of four stars, not differing more than twenty minutes in Right Ascension, arranged in two pairs, one pair to be observed in the direct and one in the reversed position of the axis. Each pair consists of a north and a south star culminating at zenith distances not exceeding 15° , and such that the mean of the clock corrections given by the members of the pair shall be free from error of azimuth. The mean of the four stars is then almost entirely free from errors of azimuth and collimation.

The following lists very nearly fulfil these conditions. The column B, for the level factor, has been omitted.

No. 10.

Star.	Mag.	R. A.			Dec.		Zenith Dist.		A.	C.
		<i>h</i>	<i>m</i>	<i>s</i>	<i>°</i>	<i>'</i>	<i>°</i>	<i>'</i>		
ϵ Perseï.....	3.3	3	50	16	+ 39	41	2	21 N.	- 0.05	+ 1.30
ζ Perseï.....	4.0	3	51	28	+ 35	28	1	52 S.	+ 0.04	+ 1.23
A' Tauri.....	4.7	3	58	1	+ 21	46	15	34 S.	+ 0.29	+ 1.08*
c Perseï.....	4.0	4	0	28	+ 47	25	10	05 N.	- 0.36	+ 1.48*

* Usually the sin of C after reversing is - instead of + as given above.—Ed.

No. 39.

Star.	Mag.	R. A.			Dec.		Zenith Dist.	A.	C.
		<i>h</i>	<i>m</i>	<i>s</i>	<i>o</i>	<i>'</i>			
β Draconis.....	2.7	17	27	53	+	53	15 03 N.	-0.40	+1.64
α Ophiuchi.....	2.0	17	59	41	+	12	24 41 S.	+0.43	+1.02
ϵ Herculis.....	3.3	17	36	17	+	46	8 44 N.	-0.22	+1.44*
μ Herculis.....	3.3	17	42	2	+	27	9 33 S.	+0.19	+1.13*

These are among the best of the lists, but there are many others nearly as good, and in very few of them is the mean of the clock corrections from the four stars affected by so much as half the azimuth error. With lists like the above it has been my practice to merely verify the position of the instrument by inspection of the mark, and if no change is perceptible to use the azimuth constant of the last measurement. For determining the level constant, Fauth & Co. have provided two excellent levels, the least sensitive of which has hitherto been used. One division of the scale = $1.04'' = 0.070s$. The radius of curvature is 540 feet.

The probable error of a clock correction from one of these lists containing only Berliner Jahrbuch stars, with the instrumental constants well determined, is $0.02s$. If the azimuth or collimation is in error, the probable error of the clock correction, determined from the discrepancy of the results of the individual stars, will be increased, but the absolute degree of accuracy of the clock correction remains the same. An error in azimuth will be pointed out by systematic differences between the north and south stars; one in collimation by a difference between the pairs.

Of course if one star out of the list is lost, the clock correction under these circumstances will be in error. In summer this is not likely to happen. In winter very frequently the regular list cannot be observed, and instead the brightest stars must be selected. The azimuth mark is then very useful, as

* Usually the sin of C after reversing is - instead of + as given above.—ED.

by means of it a good value of the clock correction can be obtained from a single star. The collimation of the transit telescope is fairly constant.

As the azimuth does not have to be deduced from the observations, the reductions are the simplest possible, and I doubt whether an equal number of observations could be made to give a more accurate value of the clock correction than that obtained by this arrangement.

Having now described the methods practiced at the observatory for the transmission of accurate time, I pass to a consideration of the different uses made of the signals outside of the observatory. Of the four pairs of points of the large relay in San Jose, one is used by the Southern Pacific Company, one by the Sunset Telephone Company, one by a jeweler in San Jose, and one was intended for use by the South Pacific Coast Railroad. The recent purchase of the latter road by the Southern Pacific Company leaves at present one pair of points unused.

The noon time signals are sent automatically over the Southern Pacific Company's telegraph lines to Oakland, where an operator, tapping his key in coincidence with the clock beats on his sounder, sends them over the general system of the company, causing the beats to be heard in every station on the lines as far as Ogden and El Paso. This method of repeating, although not quite so accurate for scientific purposes as an automatic one, is more certain and better adapted to the requirements of railroading. On the pier in Oakland, where the signals are received, a chronometer is kept which is rated by means of the signals, and is used in case of any accident to the lines connecting the office there with San Jose. Large clocks at the ferry slips in San Francisco, which are furnished with the correct time by signals transmitted by cable from Oakland, regulate the departure of the ferry boats, and also of the various lines of cable cars which start from the foot of Market Street.

The second pair of points is connected by a wire with the central telephone office in San Jose, about a quarter of a mile

from the railroad station, and the clock signals can be repeated on a sounder in the office, or the current from four Fuller's cells sent directly through any telephone in San Jose, San Francisco, or elsewhere in the system. The city hall clock of San Jose is struck, by an electric arrangement, from the telephone office.

The third pair of points is connected by a private wire with the shop of Mr. W. D. Allison, a leading jeweler in San Jose, and repeats the clock signals on a relay near his regulator. Mr. Allison is introducing a local system of time distribution, with electrically controlled clocks like those already described in use at the observatory.

It will be seen that the observatory signals are sent over a great extent of country. There has nevertheless been no defect in the proper working of the whole and all the arrangements now in use have been found satisfactory. The only causes liable to interrupt the regular transmission of the signals are accidents in winter to the line connecting the observatory with San Jose, and it has been shown that means are provided for the detection of any fault here, and its speedy remedy.

It may be of interest, in closing, to give a few notes on the atmospheric conditions prevailing at the observatory at different seasons of the year. Much has been written on this subject, but the previous tests were all made during the most favorable period. The time and other observations which have now been made here continuously for some fourteen months, give the means for making a fairly accurate estimate of the chances for good observing throughout a complete cycle of the seasons.

An estimate of the "seeing" was made each night on a scale of 5; 5 representing perfect definition and 0 impossibility of observation. These estimates refer to the state of the atmosphere up to midnight only, and therefore represent conditions more unfavorable than those which actually obtain, as high winds after sunset, which are almost invariably accompanied by bad definition, frequently die away after midnight, and the

"seeing" becomes good in the early hours of the morning.

The difference between the summer and winter months in regard to the suitability of the nights for astronomical observation is enormous. During the summer a bad night is exceptional, and the average "seeing" is at least 4 on the above scale. On a fine night I have watched the image of Polaris crossing the lines of the transit instrument with as little tremor as if it were a material point moving on the reticle. I have seen a bright star (Vega) with a small spy-glass, when at a true zenith distance of 91° . Stars culminating at a zenith distance of 87° can be well observed with the transit. This estimate of the seeing during the summer nights does not, I think, differ much from those of Mr. Burnham and Professor Comstock.

During the winter, on the contrary, the atmospheric conditions are very unfavorable, and for two months it is doubtful whether astronomical work could be pursued to advantage. The following table shows the record for the winter of 1886-87:

	Dec.	Jan.	Feb.	Mar.
Average seeing on scale of 5.....	2	2	1½	2½
Number of good nights (rated at 4).....	3	2	2	5
Number of fair nights (rated at 3).....	8	11	8	16
Number of nights on which observation was impossible...	6	5	13	5

THE RELATION OF AEROLITES TO SHOOTING STARS.*

PROF. DANIEL KIRKWOOD.

The writer more than twenty years since gave reasons for believing that shooting stars, fire balls and meteoric stones move together in the same orbits.† The facts then collected were deemed sufficient to sustain the theory advanced, or at least to give it a high degree of probability. This view has been rejected, however, by several eminent astronomers, and

* Read before the American Philosophical Society, April 15, 1887.

† Meteoric Astronomy, Chap. v.

especially by the present Astronomer Royal for Ireland, the distinguished author of "The Story of the Heavens." He remarks: "It is a noticeable circumstance that the great meteoric showers seem never yet to have succeeded in projecting a missile which has reached the earth's surface. Out of the myriads of Leonids, of Perseids, or of Andromedes, not one particle has ever been seized and identified. Those bodies which do fall from the sky to the earth, and which we call meteorites, never come from the great showers, so far as we know. They seem indeed to be phenomena of quite a different character to the periodic meteors" (*Story of the Heavens*, p. 349).

In pointing out the coincidence in the epochs of shooting stars and meteoric stones,* the present writer neglected to assign an obvious reason for the fact that star showers are so seldom observed at the same time with the fall of aerolites: a majority of the latter have been seen in the day time, when ordinary shooting stars would be invisible. At night, however, the phenomena have more than once occurred at exactly the same time. The writer called special attention to one of these epochs as long since as 1881.† In describing the shower of April meteors as it occurred in the year 1094, the historian says: "At this period so many stars fell from heaven that they could not be counted. In France the inhabitants were amazed to see one of them of great size fall to the earth, and they poured water on the spot, when to their exceeding astonishment, smoke issued from the ground with a hissing noise."‡ A few other examples are given below:

(1) During the meteoric display which continued through three consecutive nights in the latter part of October, A. D. 585, a globe of fire, sparkling, and producing a great noise, fell upon the earth.§

(2) A simultaneous fall of aerolites and shooting stars is

* *Metr. Astr.*, pp. 58-64.

† *Science*, Feb. 5, 1881, p. 59.

‡ *Am. Journ. of Sci.*, Jan., 1841, p. 356.

Quetelet's *Physique du Globe*, p. 291.

indicated by the phenomena of 1029, as described in the catalogues of Herrick and Quetelet.

(3) But without quoting other records which imply the existence of aerolites and ordinary meteoric matter in the same streams or clusters, it is sufficient to refer to the recent and very decisive phenomena of November 27, 1885.* During the periodic star shower from the fragments of Biela's comet a mass of meteoric iron weighing about ten pounds was seen to fall near Mazapil, Mexico, in lat. $24^{\circ} 35' N.$, long. $101^{\circ} 56' 45'' W.$ from Greenwich. The evidence afforded by the phenomena of 1094 and 1885, apart from the other cases cited, renders the co-existence of large and small masses in the same meteor streams almost infinitely probable.

THE LIFE AND ACHIEVEMENTS OF ALVAN CLARK.

THE EDITOR.

During the last month much has been said, in various public journals, concerning the life and the achievements of Alvan Clark, senior, of Cambridge, Massachusetts, whose death occurred at a little past 3 o'clock on the morning of August 19, 1887. Most of the accounts which have come to our notice have been brief and fragmentary, and sometimes inaccurate in statement of fact. For these reasons another attempt is made for the benefit of the readers of the MESSENGER.

Alvan Clark was born at Ashfield, Mass., March 8, 1804. His early life was spent on a farm, and all the education he received was obtained in the public schools of western Massachusetts. At the age of twenty-two he secured the situation of calico engraver at Lowell, Mass., having an aptitude for drawing which he developed without assistance. For nine years he followed this occupation, and in 1835 he removed to Boston and opened a studio for painting miniatures. For twenty years he followed the profession of artist, producing some of the best portrait pictures made by the professional

* *Am. Journ. of Sci.*, March, 1887, p. 221.

artists of his day. At the age of forty he was led to the study of technical optics by the following circumstance, in his own words :

"My son Alvan G. Clark was at Andover studying to be an engineer. His young mind seemed to be absorbed in telescopes. I was a portrait painter then, and I began to study mechanics and astronomy so as to instruct my boy. We experimented together and succeeded in making a reflecting telescope. One of the Cambridge professors was much pleased with some instruments we made, and when we suggested to him that we would like to manufacture improved instruments, he gave us great encouragement and we went ahead."

Speaking of the character of the work which the Clarks did from the first, Professor Holden, director of Lick Observatory, in a late article in the *Examiner*, fittingly says :

"Like the elder Herschel he was obliged to manufacture his own telescopes. Like Herschel, too, he began by making reflectors, but he soon abandoned them for refracting telescopes. His early efforts were most successful, and he began to make 6 and 8-inch object glasses of an unheard of excellence and precision. One of these found its way to England and came into the possession of the Rev. W. R. Dawes, an amateur of astronomy and a devoted observer of double-stars. The extraordinary defining power of Clark's object glasses admirably fitted them for this kind of work. It is no exaggeration to say that the separating power of one of Clark's 6-inch object glasses of 1850 was equal to the separating power of the nine-inch objectives of that day. Dawes made Clark's telescopes known in England by his own observations and by recommending his friends to purchase them, and it was not long before quite a number of Clark's object glasses were scattered over England and Scotland.

"They were mostly of small size, 6 to 8 inches. By this time Clark was able to give up his portrait painting, and to devote his life and those of his two sons, George and Alvan G. Clark, to the manufacture of object glasses exclusively.

"It must be remembered that this is no common manufacture ; but that it is a process which involves special mechanical talent of the highest order, beside mathematical and optical learning.

"To give an idea of the perfection of a good object glass, it

may suffice to say that its geometrical figure is so precise that if the glass were to be rubbed with the finger only round and round in a circle for five or ten minutes there would be a perceptible falling off in the precision of the star-images seen with it; or to put the same thing in another way, I may say that theoretical optics shows us just how near two bright points (stars) may be and yet be seen separated with an object glass of a given aperture. And the Clarks long ago succeeded in making every one of their telescopes practically do what theory demanded. That is, the telescopes were perfect.

"After making the smaller telescopes, the Clarks began to make 12 inch object glasses, and some of these of their manufacture are probably the most perfect of any in the world. Mr. Clark has often said to me that the 12-inch objective at Middletown, Conn., and the 12-inch at the Lick Observatory (formerly the property of my friend Henry Draper), were the best that he had ever seen. A 6-inch which he made in 1870 for Mr. Burnham of Chicago, has had a wonderful history—no less than 1,000 new and difficult double-stars having been discovered by its use.

"The 18-inch telescope now at Chicago was finished just before the war for the University of Mississippi, and was at once made noted by the discovery of a companion star to Sirius, which theory predicted, but which no one had detected before it was seen by Alvan Clark, Jr.

"Alvan Clark, Sr., himself discovered quite a number of difficult and interesting double stars. In 1873 the great 26-inch telescope was made by the Clarks for the Naval Observatory in Washington. With this telescope Professor Newcomb and myself observed the faint satellites of Uranus, which had not been seen by any one but their discoverer, Lassell; and with this Professor Hall discovered the faint satellites of Mars. Some idea of the seeing power of such instruments may be had when I say that the faintest satellite of Mars has just such an angular magnitude as a small terrestrial school globe would have if it were placed on the State House in Boston and looked at from the Capitol at Washington.

"The 26 $\frac{1}{4}$ -inch for the University of Virginia, the 23-inch for Princeton College, the 30-inch for the St. Petersburg Observatory soon followed, and finally the 36-inch for Mt. Hamilton."

The varying sizes of the lenses made by the Clarks range in inches as follows: 6, 8 $\frac{1}{4}$, 9 $\frac{1}{2}$, 12, 15 $\frac{1}{2}$ (Washburn), 18 $\frac{1}{2}$ (Chicago Astronomical Society), 23 (Princeton College), 26 (U. S.

Naval Observatory), 26¼ (University of Virginia), 30 (Pulkowa Observatory, Russia), and 36 (Lick Observatory, Cal.). The cost of the Washington telescope was \$46,000, the Pulkowa glass \$33,000, and the Lick glass was \$50,000. These large figures indicate another way of measuring the opticians' skill of which we are now speaking.

If we remember that this was the work of a man who had never seen a lens in the process of construction in the shop of another maker, we have an example of a self-made man emphatically. His skill was gained and his reputation earned by steady, hard and persistent work. If he had naturally a keen eye, a quick understanding and a most delicate touch, they were each and all used in long continued endeavor which was nothing less than the genius of successful and conquering patience. His skill as an observer was recognized by complimentary letters from the distinguished English astronomer Mr. Dawes, on account of his discovery of many new double-stars. In consequence of his discovery of the companion to Sirius, he was awarded the Lalande medal by the French Academy of Sciences, and for the successful construction of the 30-inch Pulkowa glass he was tendered a vote of thanks by the Russian Imperial Academy of Sciences, and the Czar of Russia gave him a gold medal.

Such was the career of Mr. Clark. Of his personal characteristics Professor Holden has spoken well in the article above referred to. He says:

"Mr. Clark was a man of perfectly plain and simple habits, but of singular distinction of face and manners. His countenance always showed the kindest and most sincere interest in his listeners and the truest enthusiasm for his art. His friends and admirers will remember the distinctions of his intellect and of his character longer than the memory of the honors given him by foreign governments will last. But so long as astronomy is followed by cultivated and intelligent man, so long will his real and conspicuous advances in the art of making telescopes be remembered and celebrated. His was a long, an honorable, a simple and a good life. It has come to a natural close, but it has left behind it kindly memories on all who knew him, and an undying fame in the annals of science."

THE YALE COLLEGE MEASUREMENT OF THE PLEIADES.*

A. M. CLERKE.

The Messrs. Repsold have established, and for the present seem likely to maintain, a practical monopoly in the construction of heliometers. That completed by them for the Observatory of Yale College in 1882 leaves so little to be desired as to show excellence not to be the exclusive result of competition. In mere size it does not indeed take the highest rank; its aperture is of only 6 inches, while that of the Oxford heliometer is of $7\frac{1}{2}$; but the perfection of the arrangements adapting it to the twofold function of equatorial and micrometer, stamps it as a model not easy to be surpassed. Steel has been almost exclusively used in the mounting. Recommended as the material for the objective-cell by its quality of changing volume under variations of temperature nearly *pari passu* with glass, its employment was extended to the telescope-tube and other portions of the mechanism. The optical part of the work was done by Merz, Alvan Clark having declined the responsibility of dividing the object-lens. Its segments are separable to the extent of 2° , and through the contrivance of cylindrical slides (originally suggested by Bessel) perfect definition is preserved in all positions, giving a range of accurate measurement just six times that with a filar micrometer. (Gill, "Encyc. Brit." vol. xvi, p. 253; Fischer, *Sirius*, vol. xvii, p. 145.)

This beautiful engine of research was in 1883 placed in the already practiced and skillful hands of Dr. Elkin. He lost no time in fixing upon a task suited both to test the powers of the new instrument and to employ them to the highest advantage.

The stars of the Pleiades have from the earliest times, attracted the special notice of observers, whether savage or civilized. Hence, on the one hand, their prominence in stellar

* "Determination of the Relative Positions of the Principal Stars in the Group of the Pleiades." By William L. Elkin. Transactions of the Astronomical Observatory of Yale University. Vol. I, Part I. (New Haven: 1887.)

mythology all over the world ; on the other, their unique interests for purposes of scientific study and comparison. They constitute an undoubted cluster ; that is to say, they are really, and not simply in appearance, grouped together in space, so as to fall under the sway of prevailing mutual influences. And since there is, perhaps, no other stellar cluster so near the sun, the chance of perceptible displacements among them in a moderate lapse of time is greater than in any other similar case. Authentic data regarding them, besides, have now been so long garnered that their fruit may confidently be expected at least to begin to ripen.

Dr. Elkin determined, accordingly, to repeat the survey of the Pleiades executed by Bessel at Königsberg during about twelve years previous to 1841. Wolf and Pritchard had, it is true, been beforehand with him ; but the wide scattering of the grouped stars puts the filar micrometer at a disadvantage in measuring them, producing minute errors which the arduous conditions of the problem render of serious account. The heliometer, there can be no doubt, is the special instrument for the purpose, and it was, moreover, that employed by Bessel ; so that the Königsberg and Yale results are comparable in a stricter sense than any others so far obtained.

One of Bessel's fifty-three stars was omitted by Dr. Elkin as too faint for accurate determination. He added, however, seventeen stars from the Bonn *Durchmusterung*, so that his list comprised sixty-nine, down to 9.2 magnitude. Two independent triangulations were executed by him in 1884-85. For the first, four stars situated near the outskirts of the group, and marking the angles of a quadrilateral by which it was inclosed, were chosen as reference-points. The second rested upon measures of distance and position-angle outward from Alcyone (γ Tauri). Thus, two wholly unconnected sets of positions were secured, the close accordance of which testified strongly to the high quality of the entire work. They were combined with nearly equal weights, in the final results. A fresh reduction of the Königsberg observations, necessitated by recent improvements in the value of some of the corrections em-

ployed, was the preliminary to their comparison with those made, after an interval of forty-five years, at Yale College. The conclusions thus laboriously arrived at are not devoid of significance, and appear perfectly secure, so far as they go.

It has been known for some time that the stars of the Pleiades possess a small identical proper motion. Its direction, as ascertained by Newcomb in 1878, is about south-south-east; its amount is somewhat less than six seconds of arc in a century. The double-star 61 Cygni, in fact, is displaced very nearly as much in one year as Alcyone with its train in one hundred. Nor is there much probability that this slow secular shifting is other than apparent: since it pretty accurately reverses the course of the sun's translation through space, it may be presumed that the *backward* current of movement in which the Pleiades seem to float is purely an effect of our own *onward* traveling.

Now the curious fact emerges from Dr. Elkin's inquiries that six of Bessel's stars are exempt from the general drift of the group. They are being progressively left behind. The inference is obvious, that they do not in reality belong to, but are merely accidentally projected upon, it: or rather, that it is projected upon them; for their apparent immobility (which, in two of the six, may be called absolute) shows them with tolerable certainty to be indefinitely more remote—so remote that the path, moderately estimated at 21,000,000,000 miles in length, traversed by the solar system during the forty-five years elapsed since the Königsberg measures, dwindles into visual insensibility when beheld from them! The brightest of these six far-off stars is just above the eighth (7.9) magnitude; the others range from 8.5 down to below the ninth.

A chart of the relative displacements indicated for Bessel's stars by the differences in their inter-mutual positions as determined at Königsberg and Yale, accompanies the paper before us. Divergences exceeding 0.40" (taken as the limit of probable error) are regarded as due to real motion; and this is the case with twenty-six stars besides the half-dozen already mentioned as destined deserters from the group. With these

last may be associated two stars surmised, for an opposite reason, to stand aloof from it. Instead of tarrying behind, they are hurrying on in front. An excess of the proper movement of their companions belongs to them; and since that movement is presumably an effect of secular parallax, we are justified in inferring their possession of an extra share of it to signify their greater proximity to the sun. Hence, of all the stars in the Pleiades these are the most likely to have a measurable annual parallax. One is a star a little above the seventh magnitude, distinguished as *s* Pleiadum; the other, of about the eighth, is numbered 25 in Bessel's list. Dr. Elkin has not omitted to remark that the conjecture of their disconnexion from the cluster is confirmed by the circumstance that its typical spectrum (as shown on Prof. Pickering's plates) is varied in *s* by the marked character of the K line. The spectrum of its fellow-traveler (No. 25) is still undetermined.

It is improbable, however, that even these nearer stars are practicable subjects for the direct determination of annual parallax. By indirect means, however, we can obtain some idea of their distance. All that we want to know for the purpose is the *rate* of the sun's motion; its *direction* we may consider as given with approximate accuracy by Airy's investigation. Now, spectroscopic measurements of stellar movements of approach and recession will eventually afford ample materials from which to deduce the solar velocity; though they are as yet not accurate or numerous enough to found any definitive conclusion upon. Nevertheless, M. Homann's preliminary result of fifteen miles a second as the speed with which our system travels in its vast orbit, inspires confidence both from the trustworthiness of the determinations (Mr. Seabroke's) serving as its basis, and from its intrinsic probability. Accepting it provisionally, we find the parallax of Alcyone = about $0.02''$, implying a distance of 954,000,000,000 miles, and a light-journey of 163 years. It is assumed that the whole of its proper motion of $2.61''$ in forty-five years is the visual projection of our own movement towards a point in R. A. 261° , Decl. $+25^\circ$.

Thus, the parallax of the two stars which we suspect to lie between us and the stars forming the genuine group of the Pleiades, at perhaps two-thirds of their distance, can hardly exceed $0.03''$. This is just half that found by Dr. Gill for ζ Toucani, which may be regarded as, up to this, the smallest annual displacement at all satisfactorily determined. And the error of the present estimate is more likely to be on the side of excess than of defect. That is, the stars in question can hardly be much nearer to us than is implied by an annual parallax of $0.03''$, and they may be considerably more remote.

Dr. Elkin concludes, from the minuteness of the detected changes of position among the Pleiades, that "the hopes of obtaining any clue to the internal mechanism of this cluster seem not likely to be realized in an immediate future;" remarking further: "The bright stars in especial seem to form an almost rigid system, as for only one is there really much evidence of motion, and in this case the total amount is barely $1''$ per century." This one mobile member of the naked-eye group is Electra; and it is noticeable that the apparent direction of its displacement favors the hypothesis of leisurely orbital circulation round the leading star. The larger movements, however, ascribed to some of the fainter associated stars are far from harmonizing with this preconceived notion of what they ought to be. On the contrary, so far as they are known at present, they force upon our minds the idea that the cluster may be undergoing some slow process of disintegration. M. Wolf's impression of incipient centrifugal tendencies among its components certainly derives some confirmation from Dr. Elkin's chart. Divergent movements are the most strongly marked; and the region round Alcyone suggests, at the first glance, rather a very confused area of radiation for a flight of meteors, than the central seat of attraction of a revolving throng of suns.

There are many signs, however, that adjacent stars in the cluster do not pursue independent courses. "Community of drift" is visible in many distinct sets; while there is as yet no perceptible evidence, from orbital motion, of association

into subordinate systems. The three eighth-magnitude stars, for instance, arranged in a small isosceles triangle near Alcyone, do not, as might have been expected *a priori*, constitute a real ternary group. They are all apparently traveling directly away from the large star close by them, in straight lines which may of course be the projections of closed curves; but their rates of travel are so different as to involve certain progressive separation. Obviously, the order and method of such movements as are just beginning to develop to our apprehension among the Pleiades will not prove easy to divine.—*Nature*.

NOTE FROM MR. PROCTOR.

SIR:—I should have greatly preferred that what I have been forced to say respecting Prof. Holden (by his own most unwise renewal of an offense originally committed anonymously) should be forgotten. But, as you have published in the *SIDEREAL MESSENGER* for June, his letter in the *Examiner*, I must ask you to do me justice by inserting the enclosed reply. (The *MESSENGER* reaches me by the way of England and therefore very late.)

Prof. Holden, at a time when he was absolutely sickening me by false compliments at Washington (in 1874), wrote anonymously a review of a popular book of mine, in the *Atlantic Monthly*. In this he adopted the preposterous position that there is something degrading to science in writing books which more than pay their expenses; hinting plainly that since I can write books too abstruse to sell I ought so to employ all my time. I am not greatly concerned to point out that in writing books which will sell because simple (though sound), I am adopting one way of earning a livelihood, while a man who takes a position in an observatory or a professorship at college takes another, the only question affecting the propriety of any such course being whether the work is well done, and my livelihood absolutely depending on my doing my work well, whereas, as Prof. Holden's case at Washington shows, a man may be inefficient as an observer and yet retain a hand-

somely paid official post in an observatory. I should have cared nothing about the paltry sneers running through the criticism in the *Atlantic Monthly*, in point of fact they could deceive no one of any sense. But the review was full of untruths. It opened with a gross untruth, repeated in his latest letter in company with many others by Prof. Holden; and it either suggested or deliberately stated a string of untruths to the end. I had no knowledge who the author might be. Had I guessed a man associating as Prof. Holden did at the time, with men whom I esteem, was the author of it, I might have remained silent. But deeming that some dishonest penny-a-liner was the writer, I sent to the leading papers of New York a letter pointing out the dishonesty of the criticism and illustrating this by the case in which the critic deliberately denounced by name a book which had not yet appeared. He made, still anonymously, a feeble and foolish defense, offering an apology which I publicly declined to receive.

When, two years later, I found Prof. Holden was the author of the dishonest criticism, I was deadly ashamed to think a man in a responsible position in scientific circles could have been capable of such a thing. I remained absolutely silent for years. But it was the silence of contempt as well as shame,—contempt for him, and shame for the disgrace he had brought on the brotherhood of Science.

Recently he ventured, considerably to my surprise, to arouse the sleeping shame by deliberately making a series of statements about an article of mine implying that I needed to be told the very things that that article had most carefully explained,—and closing with the characteristic remark that only a Wiggins or a Vennor could make the mistake which my article anticipated him in correcting. (The reference to Wiggins, by the way, was rather dangerous for a man who had set all Washington astronomers laughing by detecting a third satellite of Mars with an impossible period and distance, and remaining deceived by it for months!)

Let me now simply state, and as briefly as possible, for this letter is running beyond the length I had intended and occu-

pying more time than I can spare the subject, that—taking renewed and new falsehoods in the order in which they appear in Prof. Holden's letter:—

1. My "Saturn and its System" was *not* a success: the first edition was eighteen years selling. I estimate my loss on the work at fully a thousand dollars.

2. No biographers have ever asserted that Saturn was a success which led me "to attempt to earn a large sum of money by writing similar books."

3. No such book as "Other Suns than Ours" had appeared when Holden wrote his review.

4. I utterly disbelieve, though I cannot disprove, his statement that in writing a review which appeared in the summer of 1874, he confounded a two-column report of a lecture of mine with a book, and did not think of this even when first defending himself in 1879 from the rather serious charge of denouncing a book which had not yet appeared.

5. The Royal Astronomical Society not only did not force me from my position as its Honorary Secretary, but Prof. Holden has always known that it did not. For it was a subject of conversation with him at Washington in March, 1874, that I had had to resign the secretaryship and the editorship of the Society's Proceedings in October, 1873, when I sailed for America. The Society never suggested resignation, and never had anything to do with the matter, beyond accepting my resignation,—which, considering I was already in America when the letter reached the hands of the council, they could not well have declined to do.

6. Prof. Holden owes it entirely to me that his name, when suggested for a Foreign Associateship of the Society, was not rejected with contempt.

7. I never coupled my name with Newton's. I spoke of Newton as the "greatest of us all." If that is coupling my name with his, then a farm lad who chanced to say that "the President is the first of us Americans" would be coupling his name in the same sense with President Cleveland's.

8. Prof. Holden knows perfectly well that his review could

not have offended me as adverse; for it was not adverse. The level of my popular writings is not determined by myself but by my readers. Prof. Holden in admitting that my "Saturn" and my "Moon" deserved to succeed, was saying all that my personal desire for appreciation could possibly require. As a matter of fact, those books, my "Geometry of Cycloids," and similar works of mine have not succeeded. I write such books at a loss. For my livelihood, which I feel fully as much entitled to as any salaried official, I have had to write down to the general public (regarded astronomically). From the new editions of "Saturn" and the "Moon," all the more difficult matter has had to be excised, and matter added which appeals more directly to the mind of the general reader, as I find it, (still in the astronomical sense) to be. If I heard my friend Prof. Young addressing a junior astronomical class at Princeton and touched on the simplicity of his discourse, I should certainly not offend him by so doing; for that simplicity would be an important quality. If I went on, however, to say he was degrading science by lowering his tone to the capacities of his class, I take it he might be indignant at the charge, unless its absurdity left no room for any feeling but amusement.

Lastly, it is well known my real offense with Prof. Holden was that I wrote the astronomy of the American Cyclopaedia.

Very truly yours,

St. Joseph, Mo., July 27, 1887.

RICHARD A. PROCTOR.

THE TOTAL ECLIPSE OF THE SUN, AUG. 19, 1887.*

The following is extracted from *Ciel et Terre* of Sept. 1, 1887:

"According to the reports received up to date, observations of the total eclipse of the sun appear to have been generally prevented by the weather. At certain points on the line of totality, the sky was completely covered; at others partially

Translated from the French for the MESSENGER by Dr. H. C. Wilson, Carleton College Observatory.

obscured by the clouds, and at Jurjewitz, among others, where our co-laborer M. Niesten installed himself, the phenomenon was observed only under very precarious conditions. However, the mission with which M. Niesten was charged was not a complete failure, and the letters and telegrams received from that astronomer permit us to hope that some new facts may be added to our knowledge concerning the nature of the principal body of our system.

"It is known that the eclipse commenced in western Europe, advancing through the north of Germany, Russia, Siberia, ending in Japan. The best stations for observing the phenomenon were to the north of Moscou in the valley of the Volga, and better still at Tobolsk.

"Few eclipses have been the objects of so considerable preparation, at Berlin, Poulkova and Moscou. Excursions were even organized at Berlin, carrying out a great number of persons desirous of contemplating the phenomenon.

"At Poulkova, M. Struve had organized fifteen or twenty scientific expeditions, national or foreign; at Rschew, to the northwest of Moscou, was M. Young; at Petrowska, on the route from Moscou to Jaroslaw, were MM. Glasenapp, Tattschaloff and Stanoiewitch, the last representing the observatory of Meudon; at Kineshma, on the Volga, (terminus of the railroad from Moscou), MM. Bredichin, Perry, Copeland, Tacchini and Ricco; at Kolkosé, M. Jegoroff.

"Beyond the Volga, access was more difficult; and even beyond the Ural the difficulties of travel became still greater, especially so near Tobolsk unfortunately, for that was the region most favorable for observation of the eclipse in its totality.

"The program of observations was thus fixed: Photography of the eclipse at all the stations; Spectroscopy, MM. Young and Tacchini; Photography of the spectrum and of the corona, MM. Copeland and Perry; Search for intra-mercurial planets, notably Vulcan, MM. Glasenapp and Tattschaloff; Solar diameter, M. Struve; Meteorological observations everywhere.

"Two balloons were arranged for observations above the clouds; the one of 700 cubic meters by the Imperial Institute

of Technology of Russia for Professor Mendlejew; the other of 1,000 meters, at Twor, for Professor Swjerinzew.

"As stated above, the news received up to the present from a certain number of observatories show that the results are almost negative, because of the state of the sky, almost wholly covered. However, at the station at Petrowska, M. Glasenapp obtained two drawings and three photographs of the corona; M. Stanoiewitch obtained the lines in the spectrum of the corona and took some photographs; M. Kononowich (of Odessa) obtained a complete spectrum of the corona.

"In conclusion we may add that at Berlin some wags had posted upon the city wall that, in view of the bad weather, the eclipse was deferred until the following Sunday."

Then follow some telegrams and extracts from letters from M. Niesten, the last of which is quite interesting:

"The dispatch which I sent to the observatory will have informed you that the photographs taken during the eclipse have given some results. These photographs were obtained during totality with an apparatus having four objectives; Dallmeyer, Ross and two Darlot. Those given by Dallmeyer are very good. In all six photographs are good and two passable. The time of exposure was about 8s for the first, 12s for the second, 16s for the third, 20s for the fourth, 24s for the fifth and 30s for the last three. The chromosphere and the protuberances were shown upon all and two show some traces of the corona, also the impression of Regulus (α Leonis), which was near the sun. What is especially important, the photographs confirm the exactness of the drawing which I made during totality.

"M. Karinne, a skillful photographer of Moscou, also took, at Jurjewitz, with a Ross objective of 7 inches, several photographs which have given results analogous to mine. On the whole the records obtained at our station are passable and I can esteem myself fortunate to have been able to accomplish a little, since almost all the other stations were unfortunate.

"At Kineshma, where were MM. Bredichin, Perry, Copeland and Miss Brown, sky covered, nothing.

"At Viatca (Tacchini, Ricco, Kleiber), nothing.

"At Warnavin (Ceraski and Sokouloff), nothing.

"At Clinn (Müller, Kempf and Scheiner of Potsdam, Hasselberg of Poulkova), nothing.

"Thus, of the foreign station, ours only have any results.

"At Katinski about 55 *verstes* to the east of our station, on the Volga, the weather was clear; the phenomenon there displayed all its grandeur. The corona was splendid and extended, according to the observers, not in a *gloire* but in concentric circles. The protuberances even were visible to the naked eye; to certain observers they scintillated and presented the different colors of the rainbow.

"The terror among the natives was great; the infants cried, the women prayed and some, after the reading of the *Evangile* which had taken place the preceding Sunday,—religious as are all the Russians—were fearful of the end of the world. The passages of the *Evangile* which are prescribed to be read at that time of the year, state in effect, that the sun will be eclipsed, the stars will fall, etc. (See gospel according to St. Matthew, ch. 24, verses 27 to 33 and 42 to 51.)

"One fact to be noted is that the darkening was so great, that the pigeons flew against the houses and the sheep ran frightened toward the stables.

"If we had had plenty of time, what an admirable phenomenon it would have been to contemplate! Under the conditions where I observed, it was even then grand."

STAR OF BETHLEHEM.

THE EDITOR.

Intelligent people have been frequently asking during the past summer where the Star of Bethlehem could be found. The impression seems to have been general that there was now to be seen somewhere in the heavens, a very bright star which should be properly called the Star of Bethlehem, meaning that notable star spoken of in the Bible, as the "Star of the East," which the wise men saw and followed, in search of

the birth-place of the King of the Jews, and which "went before them till it came and stood over the place where the young child was."

In 1884 very much was said about this star in newspapers and various periodicals in popular and religious lines of thought, awakening an interest in the minds of the uninstructed in the astronomy and the history of it, which was sometimes very intense with well-meant devotion and sometimes very ludicrous and fanciful. What lent peculiar zest to these popular fancies in the summer of that year was the appearance of the planet Venus, for a considerable time, as a bright and most beautiful object to look upon, in the western evening sky, and from this circumstance alone it was believed by many at that time that this queen of the starry host (unknown by name), was the real Star of Bethlehem.

In view of this, an article was prepared for the MESSENGER giving the substance of all that was known to the writer, about the history of that memorable star, arranged under four heads, as follows:—

1. The star may have been a miraculous light of some kind.
2. The conjunction of the planets Jupiter and Saturn first, and finally Jupiter and Mars.
3. A comet; and,
4. A new or temporary star.

On the first point astronomy, as such, could have nothing to say, because wholly beyond its province of investigation.

Regarding the second point, scholars and astronomers in the early part of the century thought and wrote much. In this Professor Encke took the lead and his conclusions that the conjunctions of the great planets which took place at the time of the birth of Christ must have been the star seen by the Magi. This opinion prevailed quite generally among astronomers, including so high authority as that of George B. Airy, Astronomer Royal of England.

Within the last few years, however, astronomers have been less confident that the theory of the conjunction of the planets is really sound. As satisfactory a statement of the theory

and its objections from the side of science as the writer has seen is found in *Knowledge*, Dec. 29, 1882, as follows:

"If the Magi set out from Jerusalem as the shades of evening closed, and the time was winter, as commonly received, then it would have been about eight in the evening, at latest, when they reached Bethlehem. And if at that hour the star lay due south, or rather to the west of south, then it must have been sixty or seventy degrees west of the point opposite the sun. This would correspond fairly with the case of the conjoined planets, Jupiter and Saturn in the third year before the birth of Christ, if we suppose the journey to Bethlehem made nearly at the time of third conjunction of these planets, or about December 5. It is in fact, on this circumstance chiefly that the planetary conjunction theory of the star in the east has been based. But the whole character of the narrative is opposed to this interpretation apart from the fact that the taxing of the Roman Empire by Augustus when Joseph and Mary went to Bethlehem (according to Luke's account) certainly did not take place till two years after the triple conjunction of Jupiter and Saturn. For Matthew says, 'Lo! the star went before them' and 'when they saw the star they rejoiced with exceeding great joy.' But they would not lost sight of the planets Jupiter and Saturn from the time when these two planets had been visible in conjunction as morning stars in May (B. C. 7) though the time of their greatest conjoined brilliancy was in September and onward until the time of their third conjunction on Dec. 5. We had a similar triple conjunction in 1877. They were conjoined as morning stars on July 27, conjoined when nearly at their full brightness on Aug. 25, and conjoined again as evening stars on Nov. 3. But all through these months they were both visible and in tolerable close proximity. The exceeding great joy with which the Magi again saw the stars shows that it had been for a time lost to them, so that we must on this account reject the planetary conjunction theory which seems otherwise (and on several grounds) altogether untenable."

As determined by Encke in 1831, the distance of these

planets apart, at conjunction, must have been one degree at least, and hence could not have appeared to an ordinary observer as one star at any time. On the other hand it is easy to see how such a striking phenomenon would arrest the attention of those interested in, or acquainted with, the Hebrew prophecy or astrology. The teachings of astrology interpreted the conjunctions of planets as foreshadowing great national events, and the sign of Zodiac called Pisces was known to belong to the Jewish nation, hence a conjunction in this sign (not only one but three) was significant of the birth of Christ the expected King. A trace of this same belief is found in Kepler's writings, in which he holds that the conjunctions of great planets coincides with the approach of climaxes in human affairs, and gives as examples, the birth of Enoch, the Deluge, the births of Moses, Cyrus, Jesus Christ, Charlemagne and Luther.

Regarding the theory that the star seen may have been a comet whose change of place might have answered the description given in the New Testament, nothing can be said by the astronomer, for he has no historical evidence to support such a claim, and he probably would not offer any other.

In the matter of the appearance of a new or temporary star at this time, as the object seen by the Magi, the records contain something of interest.

By a new or temporary star is meant one that suddenly flashes out where none has been noticed before, and as suddenly dwindles away to a telescopic star, or disappears altogether. The important stars spoken of in connection with this subject are Tycho Brahe's star and the star in *Coma Berenices*.

There is probably not another new or known variable star that has so wonderful a record as that which bears the name of Tycho Brahe. His own words best describe impressions at first sight, as follows: "Raising my eyes as usual, during one of my walks to the well known vault of heaven, I observed with indescribable astonishment, near the zenith in *Cassiopeia*, a radiant fixed star of a magnitude never before seen. In my amazement I doubted the evidence of my senses. However, to convince myself that it was no illusion, and to have the tes-

timony of others, I summoned my assistants from the laboratory and inquired of them, and of all the country people that passed by, if they also observed the star that had thus suddenly burst forth." Going on with the description Tycho Brahe speaks of its brightness as greater than that of *Sirius*, *Vega* or *Jupiter*. For splendor it was only comparable to *Venus* when nearest to the *Earth*, and was seen by some at noonday. After a few weeks it began to decline and in sixteen months became invisible to the naked eye (the telescope being invented thirty-seven years later).

In waning the star passed through changes of color, from white to yellow and red and then to white again. These phenomena interested Tycho Brahe so much that he wrote a large book describing the appearance of the star as seen by himself and others, and gave theories to account for those wonderful changes. It has since been thought that this star appeared also in 945 and 1264. If it be a variable star with period of about 314 years, it would make its time of appearance about the beginning of Christian era and also its re-appearance probable, in some slight degree, in 1886. In consequence of this latter supposition astronomers in Europe have been watching its place in *Cassiopeia*, which is now closely marked by a faint star, with special attention, for the last ten years.

In Tycho Brahe's time it was claimed by one Cardanus that this was the star which the Magi saw.

The star of *Coma Berenices* is spoken of as appearing immediately preceding the birth of Christ and was so bright as to be visible by day. Hipparchus and Ptolemy speak of this star, and Ignatius says that it "sparkled in brilliancy above all stars." Chinese records also mention a new, bright star at this time; but none of these statements have we been able to verify from the best authority. In Dr. Seiss's view of the divine origin of the constellations, the theory of this last named temporary star is certainly very suggestive and possibly not too fanciful to be true. So uncertain is all our knowledge of the Star of Bethlehem from records within our reach at the present time.

NEW WORK ON ASTRONOMY.*

RICHARD A. PROCTOR.

On January 1, 1888, will appear the first part of a Treatise on Astronomy, to be completed in twelve monthly parts and a supplementary section. In each there will be sixty-four pages, imperial octavo, many cuts, and two plates, or one large folding plate. Thus the complete volume will contain, with index, preface, etc., about 800 pages and abundant illustration. The price of each part will be 2s.; that of the supplementary section, containing tables, index, and preface, 1s. The subscription price, if paid in advance, for the twelve parts will be 21s.; the price of the complete work, bound in one volume, 31s. 6d.

The chief object of the volume thus announced is to present in popular yet scientifically sound form those views of the heavenly bodies which are included in what, in his last poem, Tennyson calls the 'New Astronomy.' The life histories of worlds and suns will be dealt with; the planets will be studied as illustrating the stages of our own earth's life, while the record of our earth will be considered as illustrating the life histories of the planets. The sun will be studied as the one star we can examine, and thus as telling us all we know in detail about the nature of other suns; and the stars will be considered as throwing light on the probable past and future of the ruling and life-giving center of the solar system.

While thus the general characteristics of the new astronomy will be presented, points of detail in which the astronomy of to-day differs from the astronomy of a quarter of a century ago will be fully considered (for the first time) in the forthcoming volume. Among these points may be specially mentioned (in the order in which they have occupied my own attention and have been accepted, or in one or two cases still await acceptance)—

1. Changed views as to the structure of our galaxy, from

* From a late printed circular.

the uniformity formerly imagined to a variety of forms, arrangement, and movements akin to what is found in the solar system, but on a much grander scale. (These views, first suggested—rather vaguely—by Dr. Whewell, were advanced definitely in 1857 by Mr. Herbert Spencer, and later, more fully by myself).

2. New views as to the sun's condition and surroundings, opening with Kirchoff's interpretation of the solar spectrum, but including many details and discoveries relating to the sun's surface, vaporous envelopes, the sierra, the colored flames, the corona, and the zodiacal.

3. Changed views (maintained by myself since 1869 and now generally adopted) as to the condition of the various orders of bodies—giant planets, terrestrial planets, moons, asteroids, etc.,—attending on the sun.

4. The recognition of the moon as presenting the history of our earth's past as well as future life—even of stages of vulcanian history whose records in the earth's case have long since been destroyed by denudation. (This I have recognized only during the last four years.)

5. Recent ideas respecting comets and meteors, by which all orders of both classes of bodies are included under one theory of volcanic ejection from suns and from planets when in the sunlike stage of their careers. (This theory is maintained in its general form at present by myself alone: but in detail by Daubree and Graham, who recognize ejection from stars; by Sorby, who recognizes ejection from our sun; by Tschermak and Meunier, who recognize ejection from our earth when in the sunlike stage. The theory is also accepted by many in one or other of these partial forms, each of which logically involves the general theory.)

I propose, further, to present in this treatise full explanations of several matters which hitherto have been either insufficiently or inexactly dealt with in all except one or two books on popular astronomy. Among them I may mention—

1. The Tides, correctly dealt with in no treatise on popular astronomy except Lord Grimthorpe's 'Astronomy without

Mathematics,' the old incorrect explanation being given in most books, and even in Herschel's admirable 'Outlines,' while a new and equally incorrect explanation (the centrifugal fallacy) appears in some recent treatises. In dealing with this subject I propose to present, in a simplified form, Sir George Airy's admirable geometrical demonstration.

2. The Precession of the Equinoxes, as a case of Gyration which is not explained accurately and sufficiently in any treatise on popular astronomy.

3. The Discovery of Neptune, correctly but not popularly dealt with by Professor Grant in his admirable 'History of Physical Astronomy,' and explained fully in Herschel's 'Outlines,' but nowhere else properly dealt with, most of the so-called explanations of the perturbations of Uranus being altogether erroneous. On this subject I have some considerations to present (not relating to the mathematical problems involved, about which there can be no question) which tend to modify the ideas commonly entertained about this interesting discovery.

The book will direct special attention to the departments of research in which astronomical work is now specially needed, endeavoring to attract towards profitable observations the many workers who are now wasting time in multiplying observations such as once had special value, but now, having achieved their purpose, possess none.

Throughout the work I shall endeavor to give a just estimate—neither exaggerated on the one hand nor inadequate on the other—of the discoveries, researches, and observations of all those students of astronomy whose work has come under my notice.

A special feature of the work will be the large number of original illustrations. I have long regarded it as unfortunate that so little has been done to improve the drawings in our books of astronomy, many of which belong, so far as style is concerned, to the astronomy of three centuries ago. The illustrations in the forthcoming work present the results of more than a thousand hours of work devoted to this feature alone.

The book itself may be regarded as the work for which all the treatises on astronomy I have hitherto produced, and also my astronomical essays and lectures, have been preparatory.

The work will be published by Messrs. Longmans & Co., to whom subscriptions (to include postage) may be sent either for parts or for the entire work.

COLORS IN THE SOLAR CORONA.

No systematic work on Astronomy, nor any special treatise, that I know of, has made any mention of the colors, or the changes of colors in the corona of the sun. Our present attempt, therefore, is altogether new and untried. We will begin by reviewing the testimony of seventeen different observers who have attentively watched the solar corona in four recent total eclipses, those which occurred in the years 1869, 1878, 1880 and 1883; all visible on the American continent, except the last which was seen by American observers on Caroline Island, in the Pacific Ocean. For convenience of reference the observers are numbered and paged. W. O. stands for the reports of the Washington Observatory for the year 1880. C. S. O. stands for the report of the Chief Signal Officer at Washington for the year 1881.

The eclipse of 1869. 1. The late Gen. Myer observed this eclipse from near Abingdon, Virginia, on the summit of White Top Mountain, 5,530 feet above the ocean level. With the telescope he saw an aureola of clear, yellowish bright light, closely surrounding the moon's disk, and fading gradually into the tint of the darkened sky with a slight tinge of purplish green. To the unaided eye the vision was magnificent beyond description. Around the black disk of the moon there was an aureola of soft, bright light through which shot out, as if from the circumference of the moon, straight, massive, silvery rays, seeming distinct and separate from each other, to a distance of two or three diameters of the lunar disk, the whole spectacle showing as upon a background of diffused rose colored light.

The eclipse of 1878. General Myer was stationed on this occasion on the top of Pike's Peak, Colorado, 14,200 feet above the ocean. He describes the corona as being white, composed of silvery rays, the inner portion towards the moon brightening in intensity of its light, but not changing its character, unless by a possible tinge of yellow, deepening slightly as it reached close to the moon. The diffused rose color which beautified the eclipse of 1869 was absent. Hence in another place he speaks of "white eclipses and red eclipses." C. S. O. pages 832-3.

2. Prof. Cleveland Abbe, of the Chief Signal Office at Washington, D. C., observed this eclipse also from Pike's Peak. He describes the dark moon, then hiding the sun, as surrounded by a narrow, brilliant, yellowish white ring, probably in breadth one-eighth of the sun's diameter. He speaks of it also as the brilliant golden ring called the inner corona. Beyond this there extended outwardly several broad rays or streamers to the distance of from two to five millions of miles, and with a breadth of a million, or a million and a half of miles. He designates them numerically. No. 1 and 5, he says, had the most delicate imaginable bluish tint, each tapering outwardly to a fine point. "The same bluish tinge pervaded No. 2 as in the case of No. 1." "No. 3 was also broader at its base, tapering to its apex like No. 1, and of the same uniform intensity and tint." C. S. O., pages 845-6.

3. Lieutenant H. H. C. Dunwoody was also at the summit of Pike's Peak and he observed with the naked eye as follows: "The moment totality commenced, the moon presented the appearance of a black disk, without indentation, surrounded by a narrow ring of orange colored light, the ring not being concentric, but wider on the right hand side, as viewed by the observer. The sun was completely surrounded by bright, silver colored rays, those of the upper left hand quadrant extending $2\frac{1}{2}$ and 3 diameters, and those in the lower left hand quadrant extending 3 or 4 diameters; the longer rays taken together presenting a fish-tail appearance." C. S. O., page 835.

4. H. T. Crosby, Chief Clerk in the War Department,

likewise on the top of Pike's Peak observed with the naked eye. He saw a circle of bright golden light consisting of fine rays radiating from the sun. The limit of this golden corona was about one-fourth of the sun's diameter above the solar surface. It was, however, seen to have a greater extension or bulging in the upper left hand and lower right hand quadrant. Beyond this circle of golden rays there extended two long streamers of silver light respectively to the left above and to the right below the sun, and to a distance of more than five solar diameters from the sun's limb. C. S. O., page 837.

5. Mr. J. H. Kerr observed from Colorado Springs, Col. He says the coronal beams were striated. The corona gave out a blue light, invisible with the telescope, but seen with the naked eye. C. S. O., page 950.

6 and 7. Lieutenant S. R. Whittall and private McCann observed together at Fort Sill, Indian Territory. The former made the discovery of the eclipse, and the latter wrote the description, which is as follows: "The sketch is, from my remembrance, a very creditable drawing. The white lines shot out and flickered uniformly; the inner circle of light during totality was of a purple hue, around which was a circle of pale yellow skirted with a circle of orange from the edge of which the irregular striæ were observed. During totality there was no appreciable change in the color of the striæ, which color was white with a yellow tinge." C. S. O., p. 875.

8. Mr. A. J. Bennet made his observations with the naked eye at Virginia City, Montana. "A ring of light of a yellowish cast surrounded the moon; brightest in the inner portion of the corona; the outer edge of the corona was sharply defined except at two opposite points where it shaded gradually away and was broken up into streaks." C. S. O., p. 883.

9. Mr. Thos. Bullock made a sketch of the eclipse at Coalville, Utah, from naked eye observations, and wrote as follows: "As it requires a master hand to imitate the beauty of a full-blown rose or a golden-banded lily, so it is utterly impossible for me to explain or describe the flickering, flaming streamers, as seen in the sketch herewith enclosed, or the gorgeous deep

golden border of rays around the sun, continually changing or moving. All who were near me exclaimed, 'Oh, how beautiful; what a glorious sight!' " C. S. O., p. 894.

10. Mr. Wm. H. Holmes, of the United States Geological Survey, was stationed in Wyoming Territory. He writes: "The sun was surrounded, while in eclipse, by minute pencils of light that played rapidly to the left and right, disappearing and reappearing; these pencils of light were very minute and quite brilliantly colored with all the colors of the spectrum. The groups of rays, as at B and C, were not constant in length and conspicuousness, but were so in position." C. S. O., p. 897.

11. Miss Olive Risley-Seward, at Colorado Springs, describes the several streamers or "shafts" which extended out from the sun. She says, "the light of these three shafts was pulsating like a flame in the breeze." "They differed distinctly in color; one showing white and brilliant like the diamond, another shining as topaz yellow, and the third as intensely yellow." W. O., p. 200.

12. Prof. Ormond Stone observed from Mount Lookout, Col. He says: "Around the sun was a narrow, bright halo, very nearly white, but slightly tinged with orange yellow." W. O., p. 238.

13. Prof. E. W. Bass, of the U. S. Military Academy, West Point, observed at Central City, Col. He says: "With the telescope I observed the corona proper. At first it appeared homogeneous, and without any particular structure, the brightness diminishing rapidly from the moon outward. But observing with care the same portion for some seconds, its minute structure became more evident. For a short distance outside of the moon's limb it apparently remained uniformly bright and white, then broke into radial streamers of the same color with intervals which were blue as seen. The streamers extended to the outer limit, expanding and blending with the blue spaces, becoming again uniform in structure." "These radiating streamers resembled very much the white ones frequently seen in auroras." "The bluish color between the streamers was faint, but unmistakable, and was due to the sec-

ondary spectrum of the objective of the telescope." "An apparent pulse or luminous wave motion continually occurred from the limb outward, reminding me again of the aurora in which similar motion is often seen. Perhaps as good a comparison would be the white streams emitted from the head of a bright comet." *W. O.*, p. 166. This attributing the blue color in the corona to the object glass of the telescope is unhappy, because the blue was seen with the naked eye by at least two other observers here quoted, the Nos. 2 and 5.

The eclipse of 1880. 14. Prof. Frisby observed this eclipse from the summit of Santa Lucia Mountain, California, 6,000 feet above the ocean. He says: "I saw around the sun what appeared to me a concentric ring of yellow light, possessing great brilliancy. I did not see any streamers or outer corona." *W. O.*, p. 399.

15. Lieutenant Christopher, U. S. N., observed from the same place and reported: "At the instant of totality a bright band of yellow light, uniform in color, and of great brilliancy, burst forth, forming a ring uniform in width, with the exception in some parts of distinct yellow protuberances rising up. The sun was slightly obscured by light cirrus clouds, preventing any view of the red flames, or a distinct view of the outer corona." *W. O.*, p. 411.

The eclipse of 1883. 16. This eclipse was observed at Caroline Island, in the Pacific Ocean, by Lieutenant Qualtrough, of the United States Navy. He reports as follows: "The moon was surrounded by a beautiful halo of silvery light, its color reminding me somewhat of the electric light, and shining through or over this halo were long white streamers, which diverged ray-like from the edge of the moon's disk." See next.

17. Dr. W. S. Dixon, U. S. N., observing from the same position, reports: "At the upper part of the corona, the first large tail of light was filamentous to a great extent, irregularly arranged, a majority of the fibers, however, assuming a curved direction trending to the right. Nearly or quite all the fibers were tinted a delicate lilac. An apparent movement among them seemed to be due to changes in the depth of

color." "At another point there were numerous narrow threads or fibers, apparently colorless, but having a more perceptible movement even than the fibers in the tail of light before mentioned. These threads were also irregularly arranged, some of them almost bowed, and presented the appearance exhibited by a wheat field during the prevalence of a strong wind." This and the preceding one are from the Report of the National Academy of Sciences: pages 142-3. It will be seen that all these extracts are from the original reports, except the one for the eclipse of 1869 which I have taken at second hand, but which I suppose is correct.

The eclipses of 1880 and 1883 were visible only at places difficult of access, and only two persons at each place were appointed to report on the corona. It is remarkable that all, without any concert, bore testimony to the colors. The eclipse of 1878 had more observers, and it is again remarkable that thirteen described the colors. This they did without any collusion, each one not knowing what the others would report. Why some others said nothing about colors will soon be explained.

Along with the colors it is of the first importance to note the movements in the coronal rays. They are described as "flickering," "flaming," "playing rapidly right and left," "pulsating like a flame in a breeze," "the appearance exhibited by a wheat field during the prevalence of a strong wind," and other tantamount expressions. For these movements see Nos. 6, 7, 9, 10, 11, 13 and 17.

Now the momentous questions arise, What is the cause of these colors, and what information do they afford about the nature of the solar corona? Happily we can obtain the necessary answers from experiments with our philosophical apparatus. As we have from long ago known how to make actual thunder and lightning, so we can produce the aurora borealis and the solar corona on a scale so reduced as to do us no harm. On an electric machine we can obtain a flash and a snap which have long been known as real thunder and lightning. Now if we put the same machine in operation in the

dark, then, from half a dozen or more parts of the machine, the electricity will be seen to fly off constantly in the form of luminous brushes. They are from two to three inches in length, and half an inch in breadth, and they are familiarly named electric brushes. They have the appearance of the tall streamers in the aurora and the corona. But they have not yet the pulsations nor the colors, for the air is too dense. But these can easily be added. Rarefy the air; and pass the electric discharge through the tube whose air has been partially exhausted. Then we see a beautiful, mild, luminous stream filling the whole tube, and flowing from the machine to the opposite discharging end. This stream or streamer goes by pulsations, by cloud-like waves. Tubes of this kind have for a century or more been called auroral tubes, because the phenomena they present are like those of the aurora. Now let us exhaust the air still more,—exhaust it so much that almost none is left. Then the electric fluid as it flows through exhibits colors. All the colors of the rainbow can be produced. These tubes, including different gases, are called Giesler tubes from their first maker. In this way it is an easy operation to make thunder and lightning and auroral and coronal streamers.

My recollections are that, in small ordinary auroras, we see no colors. But in the very tall and grand auroras of 1869 and 1870 and 1871, and in some previous exhibitions, the colors were intense and impressive; "all the colors of the spectrum," as was said about the solar corona by observer No. 10 in this article. This difference may be because the small auroras are down in the denser air, as in the auroral tube, and the tall, colored ones are farther up in the rarer air, as in the Giesler tube. Probably the same causes operate in solar coronas. Hence the unusual display of colors in the tall corona of 1878 which were reported by at least thirteen different observers.

But why were these colors not seen by many others? Because so many other deeply interesting things demanded attention. The mere catalogue of subjects to be examined scientifically in an eclipse is too long to be inserted here. It is a time of deep emotion. The mind is attracted rapidly

from one thing to another with the feeling that all will soon be over. Moreover the colors of celestial objects require time and special attention to bring them out. Often I have inquired of individuals about the colors of large stars, Sirius for example. Generally the answer is, white. But a short time of special looking brings out the true color for Sirius, white is green. Hence when there are plenty of observers each one should have but a single subject to examine. In the eclipse of 1878 very much was gained by the fact that Langley and Abbe confined their attention to the size and the form of the corona. In addition it should be stated that scientific men hitherto have felt not the least interest in coronal colors. Even after these colors have been reported by seventeen observers quoted here, and by how many more I know not, they have received during so many years not the least attention from professional astronomers. These colors are to them facts without any significance, and therefore they have been disregarded. They have been taken up by myself because my theory of the aurora and the corona makes such colors significant. It was the same with the changes in the colors of the stars. Astronomers had declared against such changes, except in the single case of Sirius. But my theory of the cause of stellar light and heat demanded such changes. Accordingly I examined and made a catalogue, with the evidences, of fifty-six stars whose colors have changed, several of them more than once. This catalogue was afterwards inserted in my volume, "The Origin of the Stars." Since then it has been added to by others.

All are familiar with the fact that when the aurora extends up in the heavens as high as 45 degrees or less, it is composed of streaks, streamers, or radiations up through which wave-like motions are seen to rise. These radiations vary in breadth, but considering the distance their width must be at least a few miles. The solar corona is composed of similar radiations. Observers call them *striæ*, filaments, and thread-like forms. Among the 22 plates in the report of the Washington Observatory on the eclipse of 1878, not less than 13 show these

striae or fine radiations. They require careful scrutiny to be seen. Observer No. 13, Prof. Bass, says that "At first the corona appeared homogeneous. But after observing with care a few seconds its minute structure of radial streamers became evident." The eminent observer Professor Langley reports, (W. O. page 209) "Now what I saw with the telescope in this brief view was a surprisingly definite filamentary structure." To be seen at all 92,000,000 miles away, they must be at least 500 miles broad,—broader, as might be anticipated, than the radiations in our northern lights. This brings out a new feature of identity between the solar corona and the aurora borealis. It is a new and a distinct subject for examination in total eclipses. My paper in the March issue of the *SIDEREAL MESSENGER* insisted on five separate points for observation in the corona. This one was accidentally omitted. Now it may be added as a sixth. It could profitably occupy the whole time of a single observer. Six men or women, therefore, each with his own special department, should be employed on the corona alone. These distinct rays or filaments are mentioned in this paper by observers Nos. 1, 4, 5, 6, 7, 8, 10, 13, 16, 17.

The corona cannot be composed of meteors falling into the sun. For the pulsations or wave-like motions all proceed outward. Nor can it be composed of meteors shot outwardly, because so dense a body of meteors constantly around the sun would most certainly stop and destroy the comets. Some of these pass within 100,000 miles of the solar surface. For further information I refer to my papers in this magazine for March and October last with the other paper therein mentioned.

J. E.

ASTRONOMY IN RECENT PERIODICALS.

Nature. In the issue of Aug. 4 of this periodical Miss A. M. Clerke reviews a late volume of Carl Braun, S. J., of Münster, Aschendorff, 1887, under the title, "A New Cosmogony." The first point raised is concerning the truth of the nebular hypothesis as given by Laplace, and the claim is made that it now no longer fits the facts, and that fairly speaking nothing is left

of it, but the naked fact "that the solar system did, somehow, originate from a primitive nebula by condensation, but further than this the whole field is open to speculation."

Dr. Braun and Wolf belong to one of the two late schools of cosmogonists which are wrestling with the Kant-Laplace scheme, and M. Faye of France is a leader in the other. Faye would abolish the old hypothesis, but Braun and Wolf would build upon it as a foundation with a method radically different from that of Laplace.

Dr. Braun's theory assumes a nebulous mass, in the beginning, co-extensive with the whole sidereal world. He thinks of this vast mass as endowed only with gravity and atomic repulsion. It is motionless, and if at any time not homogeneous, centers of attraction would form, in the process of condensation, which would eventually break up the primitive nebula into fragments, and these in turn would later become individual systems. The theory of Laplace assumed rotary motion in the beginning. Dr. Braun accounts for axial motion by the falling or inward rush of cosmical masses from space which have eccentric collisions with one another. We have a feeble illustration of the theory, in the behavior of comets at the present time in reference to the sun in the solar system. Laplace, however, thought that comets moved, by nature, in hyperbolic orbits and in ellipses by perturbation; but Faye holds that out of 364 cometary orbits computed, not one is a decided hyperbola, thus showing that the assumption of Laplace was wrong.

Another objection to the nebular hypothesis of Laplace was that it requires too swift axial rotation for the central body. The principle was that a homogeneous rotating globe should revolve more rapidly, as it contracts, in proportion to the square of the radius. Thus, when the primitive nebula was spread out to fill the orbit of Neptune, if its rotation was 165 years, (the period of Neptune's revolution), when contracted to the sun's present size it ought to rotate in 127 seconds of time approximately instead of 25 days, as will be readily proved by comparing the square of Neptune's mean distance

(2,780,000,000 miles) with the sun's radius (434,000 miles). On the contrary Dr. Braun holds that the solar nebula never had, at any time, uniform axial motion, a hint of this now being seen in the present unequal rotation of different parts of the solar surface which began by external impacts, the outer portions of the primitive mass moving most rapidly, and the inner regions slowly following from external action.

The ring theory of the planetary formation is almost wholly abandoned, and yet the comparatively even plane of planetary revolution does not seem to offer to Dr. Braun's theory insuperable difficulties, though this point is less definitely stated. The mode of obtaining planetary rotation and the revolution of accompanying satellites is ingenious and very different from the old theory. In condensing, each planet of the solar system, for example, is assumed to be about five times its present distance from the center of revolution. From these positions they would move inward and onward spirally through the general nebulous mass, sweeping paths nearly clean of cosmic matter until a balance is reached between gravity and tangential force, and then the inward approach would slowly cease. The density of these young planets consequently would be slightly increased on the inward side which would cause a whirling movement thus accounting for planetary rotation. Mention is made that this rotation, so originated, must have been in the outer parts of the planetary nebula to account for the rapid revolution of satellites, yet unborn, as compared with the slow motion of the parent mass.

Considerable is said regarding the difference of inclination to the ecliptic shown by the axes of various planets, in attempting to account for this troublesome fact. Speaking of external impacts on the inchoate earth, it is claimed that the collision of a body with it, one-thousandth part of its present mass, would have changed the inclination of its axis one degree, and, that when earth's radius was seventy times as great as now, it only needed the adverse impact of a body less than one ten-thousandth part of its own mass to stop its revolution altogether. This fortuitous way of securing the varying in-

clinations of planets, satellites and the sun itself seems quite like begging a difficulty in the theory.

Dr. Braun makes Neptune the first planet in order of production, but Faye puts it last. Because of its retrograde motion Dr. Braun supposes that it may have been condensed from a nebulous ring, but Professor Kirkwood thinks this could scarcely have been possible, because it would have required 150,000,000 years for the opposite portions of the ring to come together.

Very briefly stated, these are the outlines of the new cosmogony which plainly show much laborious thought, hard work and honest inquiry respecting the origin of things which probably science will never fully understand. That Dr. Braun has taken steps in advance is plain, but that new difficulties beset this earnest explorer's path is equally plain.

Monthly Notices for June contains a brief article from Prof. Pritchard on the parallax 61_1 and 61_2 Cygni as obtained by photography which, we believe, is the first successful attempt of the kind. The observations began May 26 last year, and were completed May 31, 1887. The work involved 30,000 bisections of star-images on 330 photographic plates procured on 89 nights. The mean results obtained are:

$$\begin{array}{lcl} \text{Parallax of } 61_1 \text{ Cygni} & = & 0.4289 \\ \text{" " } 61_2 \text{ " "} & = & 0.4353 \end{array}$$

Professor Pritchard claims that the photographic method is accurate and as reliable as other known astronomical methods.

Then follows A. M. W. Downing's comparison of star places of the Argentine General Catalogue for 1875 with those of the Cape Catalogue for 1880 and with those of other Southern Star Catalogues.

Prof. A. Auwers' Catalogue of 480 stars to be used as fundamental stars for observations of zones between 20° and 80° south declination. This working list is drawn up for astronomers in southern observatories, that a new and systematic determination of their places may be secured as early as possible. The objects sought are, better knowledge of stellar

proper motions of southern stars and aid to the Paris programme of a general photographic survey of the heavens for the epoch of 1900.

Measures of double-stars at Sydney observatory.

Professor Hough's observations of the companion of Sirius.

J. E. Gore on the orbit Σ 1757.

A. Marth's formulæ for correcting approximate elements of the orbits of binary stars.

J. G. Lohse's observations of Nova Cygni.

A. H. Wesley, the solar corona, as shown in photographs taken during total eclipses, interestingly illustrated.

Of the remaining brief papers, Edmund Neison's reply to Professor G. Hill's former article entitled "A reply to Mr. Neison's strictures on Delauney's method of determining the planetary perturbations of the moon," is prominent. Mr. Neison says that Professor Hill's criticisms of his paper show an imperfect acquaintance with the history of the question, and that they are not supported by evidence, and then notices two points in the reply.

1. That Professor Hill in justifying Delauney falls into the unquestionable error which his (Mr. Neison's) paper sought to correct by showing that Delauney had not represented Hansen rightly or fully.

2. Mr. Neison claims that by his methods of dealing with this problem there are obtained certain quantities in the coefficients of high order, depending on the higher powers of the disturbing force, which give rise to sensible values to these terms of long period, and that these values have not been obtained by Delauney's complex method, and that because they are not obtained by that method, he thinks it is bad logic to say the values themselves do not exist or are erroneous.

Astronomische Nachrichten, Nos. 2798-98 contains catalogue No. 6, 100 new nebulae by Dr. Swift of Warner Observatory. A definitive orbit of Comet 1863 IV, by Aug. Svedstrup whose elements are :

$T = 1863 \text{ Nov. } 9.52384 \text{ Berlin M. T.}$					
$\pi = 94^\circ 43' 16.2''$	$\pi' = 113^\circ 16' 32.33''$	$\left. \begin{array}{l} \text{Mean} \\ \text{Eq.} \\ 1863.0. \end{array} \right\}$			
$\omega = 357 \quad 13 \quad 50.2$	$\omega' = 21 \quad 13 \quad 11.72$				
$\Omega = 97 \quad 29 \quad 26.0$	$\Omega' = 92 \quad 3 \quad 20.61$				
$i = 78 \quad 5 \quad 2.2$	$i' = 76 \quad 6 \quad 8.31$				
$\log q = 9.8491730$	$q = 0.7065990$				

in which the elements on the left are referred to the ecliptic and those upon the right to the equator.

Following appears an article entitled, "Can the Parallax of the Fixed Stars be made Perceptible?" by Chas. H. Kummell, Washington, D. C. The instrument suggested resembles a Helmholtz telespectroscope to be used as a photograph instrument. Views of the same stars (without proper motion) are supposed to be taken semi-annually, and through the stereopic effect of such celestial objects a new method of measuring parallax is expected. It suggested also that this means would also offer an easy method of searching for stars with sensible parallax.

In No. 2800 is found new elements for Comet 1846 VI (Peters) and 1884 III (Wolf) and John M. Thome's Cordoba Observations of the Great Southern Comet 1887 I. In No. 2802 elements of the orbit of Comet 1882 I are given, and the elements of a provisional orbit for the close pair (A B) of the triple-star 12 Lyncis (Σ 948) as follows:

$P = 485.8 \text{ years}$	$\Omega = 166^\circ 30'$
$T = 1716.0 \text{ A. D.}$	$\lambda = 93 \quad 36$
$e = 0.229$	$a = 1.64''$
$r = 46^\circ 3'$	$\mu = -0.741$

After the elements follows a comparison between the recorded measures and the positions computed from the above elements.

Astronomical Journal, No. 159 concludes John N. Stockwell's paper "On certain inequalities in the moon's motion arising from the action of the planets," in which he says:

"It is therefore manifestly useless to seek for an explanation of the empirical equation discovered by Professor Newcomb

in the action of planets on the moon. In fact, the explanation of that equation which is given in (A. J.) No. 149, viz; that it is simply the correction of the adopted value of the inequality of longitude due to the oblateness of the earth, in order to reduce it to its true value, is so obviously correct that no further explanation seems necessary, at least until it has been clearly shown that the explanation there given is inadequate for the purpose."

In No. 160 appears improved elements and ephemeris of comet 1887 *e* by C. S. Chandler Jr.

A determination of the coefficients of expansion of the glass plates used for stellar photography at Cordoba, in the years 1872 to 1876, and 1880 to 1883, by Professor W. A. Rogers of Colby University. The results of a long series of observations is the establishment of the invariability of the coefficients of expansion of Bailey's metal, of Jessup's steel, and of Chance & Son's glass between the limits of -3° and $+39^{\circ}$ Fahrenheit. The critical time of quiescence for these observations was found to occur on clear days about half an hour after sunrise, and on cloudy days at a considerable later time. The absolute coefficients of expansion of the specimens of photographic glass in hand were 0.438μ and 0.412μ .

EDITORIAL NOTES.

Necessary absence from home and the State, during the early part of September, made it quite impossible to publish the MESSENGER for the month of September on time, hence the present double issue.

Recent Showers of Meteors (continued from SIDEREAL MESSENGER, April, 1887, p. 160).—Between March 13 and July 31, 1887, I saw 759 meteors during 118 hours of observation. May was a very cloudy month here, but both June and July have been exceptionally clear. The following list of radiants includes the best showers derived from these new observations:

Epoch of Shower.	Night of Max.	Radiant Point. R. A. Dec.	No. of Meteors.	Appearance.
1887.				
March 13-24.....	March 24.....	161° + 58°	7*	Rather slow.
March 21-24.....	March 23.....	190 + 20	5*	Rather swift.
March 25-27.....	March 27.....	229 + 32	5	Swift, small.
March 28.....	March 28.....	263 + 62	5	Slowish.
April 12-25.....	April 20.....	189 + 20	7*	Slow.
April 17-19.....	April 18.....	213 + 53	7	Swift, short.
April 17-25.....	April 18.....	231 + 17	10	Very swift.
April 18-20.....	April 20.....	269 + 32	16	Swift, streaks.
April 18-26.....	April 25.....	272 + 21	10	Swift, short.
June 10-17.....	June 15.....	291 + 52	8	Swift, short.
June 10-28.....	June 20.....	335 + 57	10	Swift.
June 11-19.....	June 18.....	274 + 69	9	Very swift, short.
June 12-21.....	June 15.....	285 + 23	11	Slowish.
June 13-20.....	June 18.....	302 + 24	11	Rather swift.
June 13-21.....	June 17.....	270 + 47	5	Slow, bright.
June 14-20.....	June 17.....	268 — 24	5	Very slow, bright.
June 14-26.....	June 20.....	354 + 39	6	Very swift, streaks.
June 17-22.....	June 20.....	280 + 43	10	Swift, faint.
June 17-23.....	June 17.....	252 + 11	7	Very slow.
June 21-26.....	June 25.....	238 + 47	7	Slow, small.
July 12-27.....	July 12.....	333 + 12	17*	Rather slow.
July 14-31.....	July 20.....	269 + 49	13	Swift.
July 16-31.....	July 23.....	325 + 49	16	Swift, short.
July 22-29.....	July 22.....	16 + 31	7	Swift, streaks.
July 22-31.....	July 31.....	46 + 26	7	Swift, streaks.
July 23-29.....	July 28.....	337 — 12	27	Slowish, long.†
July 27-29.....	July 27.....	260 + 69	7	Slowish.
July 27-31.....	July 28.....	34 + 18	8	Swift, streaks.
July 27-31.....	July 31.....	5 + 10	6	Swift.

* Including one or two meteors registered at same epoch in preceding years.

† This shower in Aquarius represents the special display of the July meteoric epoch. In 1883, on July 28, I found the radiant at 337° — 11°; on July 28, in 1879, at 338° — 14°; and on July 27-31, 1878, at 341° — 13°.

In addition to the above streams I observed many others apparently of less importance, except the Perseids which have really formed the richest shower of all. Between July 18 and 31 I recorded 53 meteors belonging to it, and the radiant point has exhibited the same progressive motion amongst the stars as noticed here in previous years, as will be seen by the following positions determined on various nights:

Date.	Radiant.	No. of Meteors.	
1887.			
July 19.....	R. A. Dec. 19° + 51°	4	The Perseids are swift, bright meteors, leaving phosphorescent streaks.
July 22-23.....	25 + 52	9	
July 27.....	29 + 54	5	
July 28.....	30 + 55	10	
July 29.....	31 + 54½	10	
July 31.....	35 + 54	11	

In 1885, on July 13, I saw some swift, streak-leaving meteors from 11° + 48° and I believe these were a very early display of the same stream. There is very strong if not conclusive

evidence that this celebrated shower endures from July 13 to August 22, and that the radiant advances during this interval from $11^{\circ} + 48^{\circ}$ to $76^{\circ} + 57^{\circ}$.

W. F. DENNING.

Bristol, England, Aug. 1, 1887.

Comet f 1887 (Brooks).—Under date Aug. 27, the following letter was received from Mr. Brooks concerning the discovery of the above named comet:

"On the morning of August 25th, 1887, while sweeping low down in the eastern heavens I discovered a new comet, in the constellation Cancer, approximate position R. A. $8\frac{1}{2}$ 33m, Decl. north 29 degrees. I verified the discovery by a second observation the following morning and found the comet to be moving at the rate of about $\frac{3}{4}$ of a degree daily in an easterly direction. Also observed it again this morning, August 27, when it was in field with the wide double-star ϵ Cancr and about 20' north of the star. Comet is brightish with eccentric condensation."

Elements and ephemeris of Comet *f* 1887 (Brooks), by H. V. Egbert. From observations on Aug. 26, 28 and 30, I have derived the following elements of Comet Brooks:

$$T = 1887, \text{ Oct. } 6.480 \text{ Gr. M. T.}$$

$$\left. \begin{array}{ll} \omega = 63^{\circ} & 18' \\ \Omega = 84 & 33 \\ i = 44 & 10 \end{array} \right\} \text{ App. Eq.}$$

$$\log q = 0.08719$$

$$C - O$$

$$\Delta \lambda \cos \beta = -0.05$$

$$\Delta \beta = -0.07$$

Ephemeris for Greenwich midnight:

1887.	A. R.	Dec.	Lg. r.	Lg. J.	L.
Sept. 6	9 $\frac{1}{2}$ 27m	—30° 11'	0.1164	0.3093	1.21
10	9 46	30 13	0.1096	0.3025	1.29
14	10 05	30 05	0.1036	0.2964	1.37
18	10 25	29 49	0.0983	0.2912	1.44
22	10 44	29 23	0.0939	0.2868	1.49
26	11 04	28 48	0.0906	0.2834	1.54
30	11 24	28 03	0.0884	0.2810	1.57
Oct. 4	11 43	27 08	0.0873	0.2796	1.59

These elements agree quite closely with those of the Olbers comet of 1815 and establish the identity of the two comets.

Dudley Observatory, Sept. 3, 1887.

This comet has a stellar nucleus and a faint tail. Before its orbit was known Mr. Brooks suspected its periodic character and of course is pleased to find that it is the return of the Olbers comet. We are also told by a ready computer, that the elliptical elements by Ginzel give a perihelion time which represents some observations within one minute of arc in both latitude and longitude.

This comet was first seen by Olbers in 1815, and at that time its periodicity was recognized. About three years ago its orbit was carefully investigated, and it was then announced that it would probably return in December, 1886, but the time was uncertain to the extent of one and one-half years, its period of revolution being about seventy-two years. This is especially interesting in view of the fact that it takes its place in the list of long-period comets as third, which has been established by observed return to perihelion. The other two are Halley's with period of 76 years and the Pons-Brooks comet of 1812, re-discovered by Mr. Brooks Sept. 1, 1883, and which has a period of 71 years, 4 months and 10 days. Its path for the month of September was eastward, though the constellation of Leo being nearly north of Denebola Sept. 30.

Memorandum of Miscellaneous Special Observations, recorded at the Chabot Observatory, 1886-87.—Lat. = + 37° 48' 05"; Long. = 8h 09m 06.3s W.

1886.

June 7th. Transit egress of Jupiter's Satellite III noted at 9h 26.5m local mean astronomical time. Obs'r., C. B. H.

June 13th. The occultation of star γ *Librae* by moon observed with equatorial dis. by chron. No. 1744 at 15h 06m 49.3s, chron. fast of local sidereal time 1m 15.37s, and true sidereal time = 15h 05m 33.9s. Obs'r., C. B. H.

July 1st. Eclipse reappearance of Jupiter's Satellite I noted at 15h 43m 28s on sid. chron. No. 1744, which was fast of local

sidereal time $1^m 11.5s$. Observation at $9^h 01^m 36.2s$ L. M. T. (By Amer. Ephemeris = $9^h 01^m 36.0s$.) Obsr., C. B.

July 3d. Oc. dis. of Jupiter's Satellite II noted at $9^h 13^m$ L. M. T. Atmosphere bad, and obs'n. uncertain. Obs'r., C. B.

July 5th. Occultation of "*c Leonis*," 5th mag., observed through finder of Equatorial by C. B.; obs'r. at chron., C. B. H., and time $14^h 58^m 21.8s$. Chronometer fast of local sidereal $1^h 10.5s$ and observation at $14^h 57^m 11.3s$ L. S. T.

November 12th. Occultation of "*a Tauri*," 1st mag., observed with $8\frac{1}{2}$ inch Equatorial; using sidereal chronometer No. 1744.

Dis., $23^h 23^m 45.7s$, power 300.

Reap., $00 20 02.3$ " " 50.

Both observations considered excellent; atmosphere good. Corr'n. to chron. — $00m 16.9s$ and — $00m 16.8s$, and true

Dis. = $23^h 23^m 28.8s$ local sid. time.

Reap. = $00 19 45.5$ " " "

Obs'r., Burckhalter.

1887.

February 2d. Occultations of stars in the "Hyades" cluster, with powers of 40 and 100 on the $8\frac{1}{2}$ inch Equatorial, viz.:

Star.	True L. Sid. T.	Remarks.
Dis. 70 Tauri	= $5^h 50^m 14.8s$	Not instantaneous.
" θ Tauri	= $7 51 27.1$	Good; sudden.
" Arg. + 15.633°	= $7 55 16.2$	" "
" Arg. + 15.635°	= $8 32 03.6$	" "
Reap. θ Tauri	= $8 36 55 \pm 0.5s$	Poor observation.
Dis. B. A. C. 1391	= $8 46 50.7$	Good; sudden.
		Obs'r., C. B. H.

March 29th. Occultation of "*a Tauri*," observed with Equatorial during full daylight on afternoon of this day. Dis. at $3^h 28^m 59.6s$ by sid. chron., power 90; star bright and steady. Reap., with power of 200 diameters, at $4^h 56^m 49.8$ by chron. Corr'ns. to chron. = $+ 3^m 16.3s$ and $+ 3^m 16.4s$.

Dis. = $3^h 32^m 15.9s$ local sid. time.

Reap. = $5 00 06.2$ " " "

Obs'r., C. B. H.

C. B. = Mr. Chas. Burckhalter.

C. B. H. = Mr. Chas. B. Hill.

Magnitudes of Stars for Nautical Almanacs.—Since our last issue, we have learned with pleasure that Professor Pickering proposes to publish a series of short articles on astronomical and meteorological subjects to be prepared at Harvard College Observatory. The first of this series will be on the magnitudes of standard stars of the various Nautical Almanacs now in use in different countries. Having noticed that Almanacs varied much in the brightness assigned to particular stars, and that generally the best determination was not in use, Professor Pickering proposed to the superintendents of Nautical Almanacs in different countries to furnish them a discussion of the magnitudes of the standard stars, as derived from best modern determinations. Favorable replies were received from all except England and Germany, so that the work will go forward. The plan proposed is to take for each star a magnitude which is the mean of those given by four standard authorities, the Harvard Photometry, the Uranometria Argentina, Wolff's photometric observations and the Uranometria Oxoniensis.

Total Solar Eclipse of Aug. 19.—The preparations for the observation of the total solar eclipse of Aug. 19 were probably more general and complete than ever before. The many questions that astronomers are anxiously waiting to settle by the aid of such rare and momentary opportunities as the eclipse affords, are a powerful incentive to use fully and well all such occasions when they come. The study of the corona and the chromosphere by the aid of the spectroscope and photography, the search for intra-mercurial planets, and attempts to measure the precise ratio of the apparent diameters of the sun and moon were objects of eager pursuit by a large company of observers stationed at all prominent points along the long path of the shadow. In eastern Prussia the failure was almost complete, likewise in Russia except at Petroosk, where six drawings of the corona were made and two photographs taken. At Spirous the total phase was visible twenty seconds, and at Odessa a complete spectrum of the corona was obtained.

Elsewhere nothing was obtained of value on account of bad weather, unless in northern Asia and Japan, from which sources reports are not yet received.

Note on G. C. 4333.—The description of this nebula given in the General Catalogue differs so greatly from those made at this observatory as to give rise to a suspicion of change in its appearance. It has been but little observed and unfortunately never sketched until recently. The following descriptions of it are all that I have been able to collect:

GENERAL CATALOGUE. Pretty bright, pretty small, round, gradually brighter in the middle, suspicion of resolvability.

LORD ROSS 1848. Curious circular-shaped nebula with a large dark spot at one side, around which is a close cluster of well defined, very small stars.

DR. SCHÖNFELD 1863. Round, compact, middle bright, equals a 11 or 12 magnitude star, diameter 0.3'.

1868. Perfectly round, very compact, much brighter to the middle, middle bright, equals a 11 or 12 magnitude star, diameter 0.2'.

MULLER 1887. Two nuclei forming an elliptical nebula, elongated 150° , largest diameter 26", northern nucleus brighter. A sketch shows each nucleus to be elongated in the direction $90^\circ \pm$, the center being almost devoid of nebulosity. The nuclei are entirely separated from each other except by very faint nebulosity, and are of the 12.5 magnitude.

LEAVENWORTH 1887. Irregular ring nebula, consisting of two nuclei; north nucleus brightest and clearly defined, south nucleus rather diffuse, magnitude 12.0. Sketch shows a dark spot in the center.

1887. Sketch shows two nuclei which together form an elliptical nebula with a dark spot in the center. Four very faint stars seen in the nebula; otherwise no indication of resolvability, even with power 850.

The nebula observed at this place must have been the one observed by Dr. Schönfeld, since the difference in position as compared with a neighboring star is almost absolutely the

same. While the difference in description may be due to change in the shape of the nebula, we think it more probably due to differences in size and especially power of the telescope used. Yet it is difficult to reconcile two such opposite statements as much brighter to the middle and annular with dark hole in center.

F. P. LEAVENWORTH.

University of Virginia.

Ephemeris of Comet 1887 f.—As satisfactory material is not yet at hand to correct all the elements of the orbit of Comet Olbers 1815, I have, from four observations on Aug. 27, 28, 29, 30, determined the perihelion time by the use of Ginzel's ellipse, and have based the following ephemeris upon Ginzel's elements, using the perihelion time derived as stated above.

Perihelion time was found to be Oct. 8.50398 Gr. M. T., and the other elements by Ginzel as given in Viertel. der Ast. Gesell., 17 Jahr. Zweites Heft are :

$$\left. \begin{array}{l} \Omega = 84^{\circ} 31' 24.2'' \\ i = 44 \quad 33 \quad 34.3 \\ \pi = 149 \quad 48 \quad 40.3 \\ \varphi = 68 \quad 31 \quad 03.0 \\ u = 49.387785'' \end{array} \right\} \text{Mean Equinox 1887.0}$$

The correction of this ephemeris on Sept. 16 was + 4s and - 9'', showing that Ginzel's elements are not far from the truth.

Ephemeris for Greenwich midnight :

1887.	A. R.	Dec.	Lg. r.	Lg. Δ	L.
Oct. 4	11 ^h 43.5 ^m	+27° 06'	0.0799	0.2746	1.68
8	12 02.8	26 02	0.0794	0.2740	1.69
12	12 21.7	24 51	0.0800	0.2744	1.69
16	12 40.1	23 34	0.0816	0.2758	1.66
20	12 57.9	22 12	0.0843	0.2782	1.62
24	13 15.1	20 46	0.0880	0.2814	1.57
28	13 31.6	19 17	0.0927	0.2853	1.51
Nov. 1	13 47.4	17 46	0.0983	0.2900	1.44
5	14 02.6	+16 16	0.1047	0.2952	1.37

Unit of light = Aug. 26.

H. V. EGBERT.

Dudley Observatory, Sept. 22, 1887.

Lick Observatory.—By kindness of Assistant J. E. Keeler, the MESSENGER has been informed of the progress of work at the Lick Observatory, Mt. Hamilton, Cal. The great dome for the 36-inch equatorial works beautifully. It revolves with a longitudinal pressure of 225 lbs., so that the hydraulic machinery provided is almost unnecessary, so that if water from the tank runs low the dome can be easily moved by hand. The shutters, when in place, will add something to the weight to be carried.

The castings for the lower part of the pier are already in place. The lowest section is 17 feet by 10, and is the heaviest piece, so far, hauled up the mountain. While in Cleveland recently, at the shops of Messrs. Warner & Swasey, we saw the fourth section of the pier to which the axes and telescope tube are to be attached. When in place the entire pier will be 36 feet high, measuring from the floor of the observing room to the center of motion of the telescope. The polar axis lay beside the head-piece of the pier, and it is apparently a noble piece of steel, as hard as it could be made, one foot in diameter and 10 feet long, weighing one and one-half tons.

The mechanical device resorted to by the makers to overcome the thrust on the lower bearings of the polar axis, occasioned by its own weight and the weight of the telescope when in place, is novel and ingenious. In the adjacent faces of the two main bearing plates two circular and concentric tracks are cut large enough to receive steel balls three-fourths of an inch in diameter. These grooves are filled close with these balls, allowing the plates to have only small pressure on each other, thus changing the large part of sliding friction into rolling. A method somewhat similar is adopted for the declination axis. By these auxiliaries it is confidently believed that this immense tube will be under easy control of a single person with the aid of dangling ropes or other inconvenient tackle used sometimes to harness large telescopes.

From the floor a winding stairway of iron is placed at the south end of the pier, with a landing at the base of the head-piece of the column, where an opening in pier is made and within is placed the great driving clock for the telescope. Within the pier, at this height, is space enough for a man to walk around the clock, examine and adjust all its working parts. Continuing up the stairway about twelve feet higher a second landing extending around the pier, with railing, is

reached, which brings the observer near the great circles and all the quick and slow motion apparatus for controlling the telescope. This platform is the place of the assistant observer in working hours, when the astronomer desires such help. Any change of instrument or reading of circles, however, can be done independently by the observer at the eye-piece without the aid of the assistant.

The making of the great tube, 56 feet long and four feet in diameter at the ends, with greater diameter at the middle, seemed no small task, as its sections were being drilled and fitted by special machinery made for this particular work by Warner & Swasey.

The mounting is being pushed forward with all desirable haste, considering the many difficult problems which these makers have been compelled to solve by their own skill, as machinists, for they have no precedents to go by. A few days more only are needed to complete it, and then it will be transported to Mt. Hamilton where a great dome 75 feet in diameter will be in readiness for it.

Mr. Alvan G. Clark has just returned from Paris where arrangements were made, as we are informed, for a disc for a photographic corrector to take the place of one broken in the process of grinding a few months ago.

Concerning the work on subsidiary instruments in the hands of J. A. Brashear, of Allegheny City, and Messrs. Fauth & Co., of Washington, D. C., more will be said in our next issue.

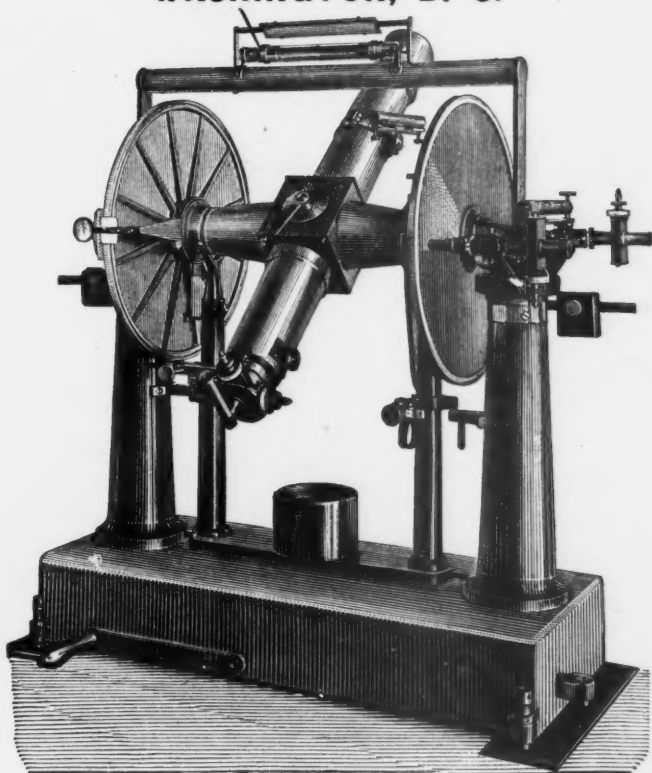
Corregenda in Various Star Catalogues.—Dr. C. H. F. Peters has done further excellent service to astronomy in the detection of errors in various star catalogues and in publishing them under the above title as an eleventh memoir in the Proceedings of the National Academy of Sciences. The catalogues containing errors so noticed are Oeltzen's Catalogue of Argelander's Southern Zones, the Catalogues of Vol. VI of the Bonn Observations, Weisse's Bessel, Runkler's Catalogue of 12,000 Stars (old and new series), Schjellerup's Catalogue, Bailey's Lalande, Yarnell's Catalogue (2d ed.), Glasgow Catalogue, Moesta's Santiago Observations, and the Geneva Observations 1842-49.

The paper also contains a list of "anonymous" identified in other catalogues.

The care with which Dr. Peters does all work is guarantee that no pains has been spared to give best results possible with means within reach.



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TRANSIT CIRCLE.—4 inch objective. 16 inch circles.

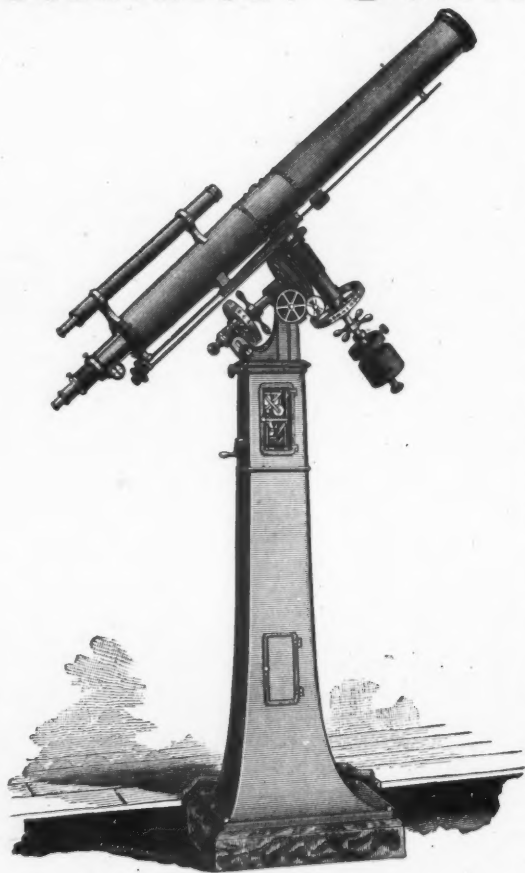
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